STUDY OF MOTORISED COMMERCIAL VEHICLES IN KANPUR AND DEVELOPMENT OF VARIOUS IMPROVEMENT MEASURES

by

SURENDRA KUMAR K. S. BAJPAI

DEPARTMENT OF CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

SEPTEMBER 1993

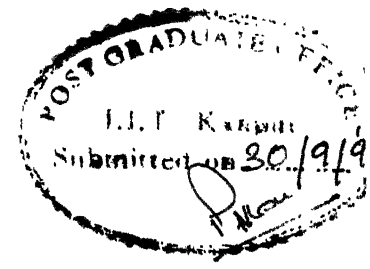
STUDY OF MOTORISED COMMERCIAL VEHICLES IN KANPUR AND DEVELOPMENT OF VARIOUS IMPROVEMENT MEASURES

A Thesis Submitted
in Partial Fulfillment of the Requirements
for the Degree of
MASTER OF TECHNOLOGY

by
SURENDRA KUMAR K. S. BAJPAI

to the

DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY, KANPUR
SEPTEMBER 1993



CERTIFICATE

This is to certify that the thesis " STUDY OF MOTORISED COMMERCIAL VEHICLES IN KANPUR AND DEVELOPMENT OF VARIOUS IMPROVEMENT MEASURES " submitted by Surendra Kumar K.S. Bajpai in partial fulfillment of the requirements for the degree of Master of Technology of the Indian Institute of Technology, Kanpur is a bonafide research work carried out by him under my supervision and guidance. The work embodied in this thesis work has not been submitted elsewhere for the award of a degree.

September, 30, 1993

(Dr B.R. MARWAH)
Professor
Department of Civil Engineering
Indian Institute of Technology
Kanpur

ACKNOWLEDGEMENT

To the remotest corner of my heart, I can not visualise the epitomizing of my thesis work without the help of some of my near and dears.

First and foremost, I would like to thank Dr. B.R. Marwah whose relentless efforts in guiding me was instrumental in completion of my thesis work. His warmth affection encouraged me to deeply attempt in solving the goods loading and unloading pattern problem associated with this study.

It is a matter of pleasure for especially thanking to Sri Pradeep Tiwari, Executive Engineer (Traffic), Kanpur Municipal Corporation and other staff members for their constant support in my mental reformation about the M.Tech. course and associated problems.

It is worthy to mention the names of Anoop Kumar Saxena and Vishwanath Jangid for giving useful suggestions and support in completing the thesis work.

Last but not the least, I am highly indebted to my parents, wife and other family members for encouraging me to strive for the excellence. Their hope and aspirations related to my progress provided impetus to work assiduously and with more vigour.

SURENDRA KUMAR K.S. BAJPAI

ABSTRACT

Kanpur is the largest city of Uttar Pradesh. Massive growth in population density and trade affairs, has plagued the transport system of Kanpur. The city road network succumbed due to encroachment, unsystematic planning, inter-mixing of slow with fast and heavy with light mode of transport, resulted in to sub standard level of service and low travel speed and massive road accidents.

In the present study it is attempted to have a detailed study of existing pattern of truck movement, through volumetric survey, loading \ unloading patterns, growth in intra-city and inter-city movements and problems of Transport Nagar area. In the light of above various remedial measures are proposed.

Traffic volume survey, specific for trucks, have been done at sixteen identified intersections at different identified cordons. Analysis of future growth of trucks for the year 2001 has been done, by taking previous decadal growth rate as basic data, and future traffic problems are assessed. For all the identified intersections and also around Transport Nagar area.

Inter-city freight transport has been analysed by calculating the inter-city growth rate in truck movement. Different best fit equations have been determined by taking relationship between truck volume with time and truck volume with population. These help in determining the future truck demand for the year 2001. A model is also developed and checked. This can also be used for forecasting the inter-city traffic demand.

To have a feel of loading pattern data is collected from different weighing stations and analysed. The results show that majority of trucks are over loaded than the prescribed load limit causing the deterioration of the road surface and crest failure.

In order to proceed in solving the traffic problems, different short term and long term traffic engineering, management and education remedial measures are suggested. These measures can be enforced through improvements in critical road stretches and intersections, truck diversions, construction of missing links, restriction of heavy vehicles on certain road, one way traffic system, passing restriction, construction of new fly overs, bye pass and Transport Nagar. This can also be very well achieved by educating the truck drivers, Police personnel and implementing bodies.

STUDY OF INTER-CITY GOODS MOVEMENT

REMEDIAL MEASURES TO IMPROVE TRAFFIC CONDITIONS

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOGRAPHS

1. INTRODUCTION

1.1 BACKGROUND

Kanpur, founded on the banks of river Ganges as a military camp, has gradually developed over the years into a premier urban center because of its trading and industrial services to a vast hinter land with a population of nearly twenty five lac. It is the second largest metropolis of northern India, after Delhi and the largest city in the state of Uttar Pradesh. Increasing importance of Kanpur has led to large scale immigration of agriculture laboures from the adjoining areas. Because of considerable social and economic influences, the city of Kanpur has become vitally important not only to it's vast hinter land but to the state and nation as well.

1.2. HISTORICAL GROWTH

According to historians, Raja Hindu Singh founded the village Kanpur in about 1750 A.D. The process of Kanpur's growth leading to it's emergence as a major industrial city of India began in the late 18^{th} century when the East India Company chose this location as an important army cantonment. Important inter-city road links constructed in the early stages of Kanpur's development are :

- G.T. Road in 1832 connecting Peshawar to Calcutta and is one of the main trunk route of the country.
- Kalpi Road in 1846 connecting Jhansi to Lucknow.
- Bithoor Road connecting Kanpur with the old

To manage the affairs of the city, a municipality was formed in 1861. The early development of Kanpur was due to various industry related demands of the military and thus many cotton, woolen and leather industries were set up. In 1918, Town Improvement Bill was passed, which was later replaced by Kanpur Urban Development Act in 1945. Due to various industrial developments, Kanpur outclassed the population of Lucknow city between 1931 and 1941. After independence, the city expanded rapidly to accommodate displaced persons.

Along with the growth of population, urban area of Kanpur city has also increased. Initial setting up of two urban centers of Kanpur namely, the city and the cantonment have been joined by six other urban centers in the last forty years. These six urban centers within the city limits are :-

Armapur Estate,

Central Railway Colony,

Chakery,

I.I.T. Kanpur,

Kanpur Cantt. and

Rawatpur Station Yard.

The total area of Kanpur Municipal Corporation has also increased over time and is 261.59 Sq Kms. excluding the area of Cantonment which covers 35.09 Sq Kms. The area of Kanpur Development Authority is 829.04 Sq Kms. (KDA, 1992)

1.3. NEED AND OBJECTIVE OF THIS STUDY

The transport system of the metro which had been instrumental in the physical expansion and concentration of

economic activities, is today plagued with numerous problems. The city road network system today presents alarmingly deteriorated conditions caused due to encroachment, on street parking and inter-mixing of slow and fast modes of transport. It is observed that travel speed along the major corridors is extremely low and the level of service has come down to almost a "stop and go situation" at some places, thus resulting in high transportation cost.

In Kanpur the space available for transportation works out to only 13.09 percent,which is much below the minimum acceptible urban developments standards. Acute shortage of off-street parking facilities, poor and inadequate control on street parking in central areas and Transport Nagar area have resulted in substantial loss of limited road space and thus has raised the congestion level in the city.

In the past, Town and Country Planning Department, Lucknow and Kanpur Development Authority have worked on foregoing issue and developed a comprehensive Master Plan of the city. In the Master Plan, commercial and residential areas have been separated, provisions for sufficiently wide roads have been made but due to lack of enforcement, attention and funds, roads have not been widened to desired capacity level. This resulted in massive encroachment and non-traffic uses of pedestrian paths. Areas initially meant for residential purposes have become semi commercial, generating traffic demands of commercial and heavy vehicles on the narrow road width in those areas. This has caused utter confusions in traffic flow and resulted into various types of accidents.

The present study attempts to have a detailed study on existing pattern of truck movement through data collection at various locations, loading and unloading patterns, growth of inter-city and intra-city truck movement and analyse the problems in Transport Nagar area which has very heavy flow of trucks. In the light of above analysis, it is proposed to suggest various remedial measures for the management of goods transport in the city.

It is aimed that suggested measures will be the working guidelines to different city organisations for effective management of truck traffic.

1.4. SCOPE OF THE STUDY

The scope of this study is problem specific. This involves study of different parameters and aspects of road system, characteristics of traffic, identification of problematic conditions and spots and their possible solutions for the redressal of the deteriorated and hazardous goods movement in Kanpur city.

To achieve the above objectives, scope of this study is restricted to the following :-

- Study of the existing goods traffic flow in the city and it's growth pattern.
- Identifying important problematic intersections with their environment.
- Study of the goods traffic flow pattern at important intersections.

- Study of the goods movement and other related problems of Transport Nagar area.
- Development of the model for prediction of inter - city truck movement and estimation of the goods traffic demands for the year 2001.
- Study the loading characteristics of the truck movement in the city and it's impact on the road structure and it's environment.

2. STUDY OF GOODS MOVEMENT IN KANPUR

2.1 INDUSTRIAL GROWTH IN KANPUR

Kanpur is one of the biggest industrial city of India, having a high percentage of total work force engaged in this sector. There are about 79 large and medium scale industries apart from 5697 other industries in small scale sector in the district. Industries within the city are :- Panki Thermal Power Station, I.E.L., L.M.L. Vespa, Indian Explosives, J.K. Rayon, Indian Oil and other textile mills. Rania and Jaunpur Industrial Estate also house many medium and small scale industries. There are also many tanneries and leather processing industries concentrated in Jajmau and Chakeri region. There are many defence industries like Gun Factory, Ordnance Factories etc. located in southern part of the city. There are 649 industrial units registered under the factories act in Kanpur which produce Rs. 700 crores worth of industrial goods Table 2.1. (DS 1987). The details of investments, number of workers employed in different types of industries in Kanpur and adjoining districts is given in Table 2.2.

It is observed from the Table 2.1 that there is a little growth in number of working units under factories act. Though there has been slight decrease in the employed work force between 1982 to 1985, the production level has increased from Rs 571 crores to Rs. 700 crores during the same time period. The reduction in number of workers in these industries is partially due to adoption of advanced technologies. Table 2.2 presents that in kanpur city there are 79 large/medium industries

TABLE 2.1

GROWTH OF INDUSTRIES AND INDUSTRIAL PRODUCTION

IN KANPUR CITY

YEAR	*TOTAL WORKING UNITS* (Under Factories Act)	*UNITS FROM WHICH RETURNS OBTAINED*	*AVERAGE DAILY WORKERS*	*PRODUCTION* (In Crores)
1982-83	649	621	78161	571
1983-84	645	600	69021	559
1984-85	649	614	69002	700

SOURCE :- DISTRICT STATISTICS - 1987 (Table 34)

TABLE 2.2

DETAILS OF INDUSTRIES IN KANPUR REGION

TYPES OF INDUSTRIES									
KANPUR REGION	LARGE AND MEDIUM			SMALL SCALE			U.P. KHADI & VILLEGE		
	No.	Investment (In Crore)	Employment	No.	Investment (In Crore)	Employment	No.	Investment (In Crore)	Employment
KANPUR CITY	79	729.82	64730	5697	37.68	73431	1892	149.49	2931
KANPUR DEHAT	13	29.71	1524	5621	32.40	11261	3945	185.38	3538
ETAWAH	2	4.50	1082	3476	20.11	20710	2804	145.61	2730
FARRUKHABAD	5	37.08	2085	3581	20.09	24163	4020	153.11	1440
TOTAL REGION	99	801.11	69621	18375	112.28	129565	12661	634.59	10629
TOTAL U.P.	1098	9215.40	464905	246494	1472.32	1592037	165514	7698.10	260787

with employment potential of 64,730 persons, 5697 small scale units with an employment potential of 73,431 persons. The growth rate for small scale industries is observed to be more than that of large/medium sized industries. (NATPAC 1991).

The goods traffic movement for various types of industries is quite different. Out of 79 large/medium sized industries, around two dozens are equipped with rail feeder facilities for supply of raw materials and delivery of finished products, while the rest of industries depend on existing road network. The raw material and finished goods movement to and from these industries have to be necessarily passed through the busy city roads. Kanpur is also a major inter-change point for all the traffic from/to the northern and north-eastern parts of India.

2.2 FIELD STUDIES FOR GOODS MOVEMENT

2.2.1 INTRODUCTION

Inter-city goods movement is mainly by large and medium sized trucks, while intra-city goods transport is by small sized trucks, auto rickshaws, animal drawn carts, hand carts and to small scale by cycle rickshaws. Being a major industrial city, a lot of trade and commercial activities are generated in the heart of the city. There is a heavy mix of slow and fast modes both for passengers and for goods movement on various city roads.

2.2.2 REGISTERED VEHICLES IN KANPUR

Table 2.3 presents the number of registered vehicles of different types in Kanpur region during the year 1982 to 1992. It is observed that in 1982, the number of trucks registered are

TABLE 2.3

DETAILS OF REGISTERED VEHICLES IN KANPUR

DURING THE PERIOD FROM 1982 TO 1992

Year ⟶ / Mode ↓	1982	1987	1988	1989	1990	1992
Trucks	2339	5003	6034	6958	8152	9735
Bus	269	434	564	651	761	832
Mini Bus	18	35	45	58	96	152
Taxi	12	26	53	91	215	333
Car / Jeep	5402	9920	11130	12349	13639	14761
Tempo / Auto Rickshaw	879	2345	2799	3526	5455	8115
Scooter / Motor Cycle	49734	101455	118785	135939	154536	170627
Others	312	684	874	1049	1122	1150
Total Vehicles	58967	119902	140284	160621	183976	205141

Source : R.T.O. Kanpur.

only about 4 percent of total registered vehicles. The rate of growth of trucks in the last decade is more than that of other types of registered vehicles. In 1992, the number of trucks registered in Kanpur city is over 4.7 percent (9453 vehicles) of the total 2,05,141 vehicles.(RTO, K,1982-92)

2.3 PLANNING FOR FIELD STUDIES

To asses the existing traffic condition for goods vehicle on road network it is proposed to study :-

(i) Identification of road network with significant flow of goods vehicles.

(ii) Identification of the intersections, road links, accidents prone spots on the above road network.

(iii) Study the characteristics of various intersections and stretches.

(iv) Conduct of volume studies for heavy goods vehicles on the major intersections and to study the turning flow patterns.

(v) Inventory of the road system in the Transport Nagar area and study the traffic circulation and flow parameters.

2.3.1 IDENTIFICATION OF LOCATIONS FOR TRAFFIC STUDIES

In accordance with the scope of traffic studies, the city road network has been divided into the following three cordons :-

(i) *Outer Cordon* - Areas or roads placed at the outer periphery of the city. These are thinly populated in comparison with the other areas. These roads mainly cater heavy goods traffic.

(ii) *Intermediate Cordon* - Areas which are semi dense and the roads/intersections are congested and problematic. These roads mainly cater mixed traffic ie heavy goods traffic mixed with light commercial and non - commercial vehicles.

(iii) *Inner Cordon* :- Mainly central business districts and thickly populated areas. The roads mainly cater light vehicles.

Traffic volume survey was conducted on 16 identified intersections. Five of these sixteen intersections, are located on the outer cordon, while the rest eleven intersections lie between intermediate and outer cordon. The locations of these intersections along with those of cordons are shown in Fig. 2.1.

The various survey station selected for the study are:

-Rama Devi Intersection

-Yashoda Nagar Intersection

-Naubasta Intersection

-World Bank Intersection

-Kalyanpur Crossing fall on outer cordon and

-Medical College Crossing

-Fazal ganj Intersection

-Ganda Nala Intersection

-Nand Lal Intersection

-Juhi Depot Intersection

-Bara Devi Intersection

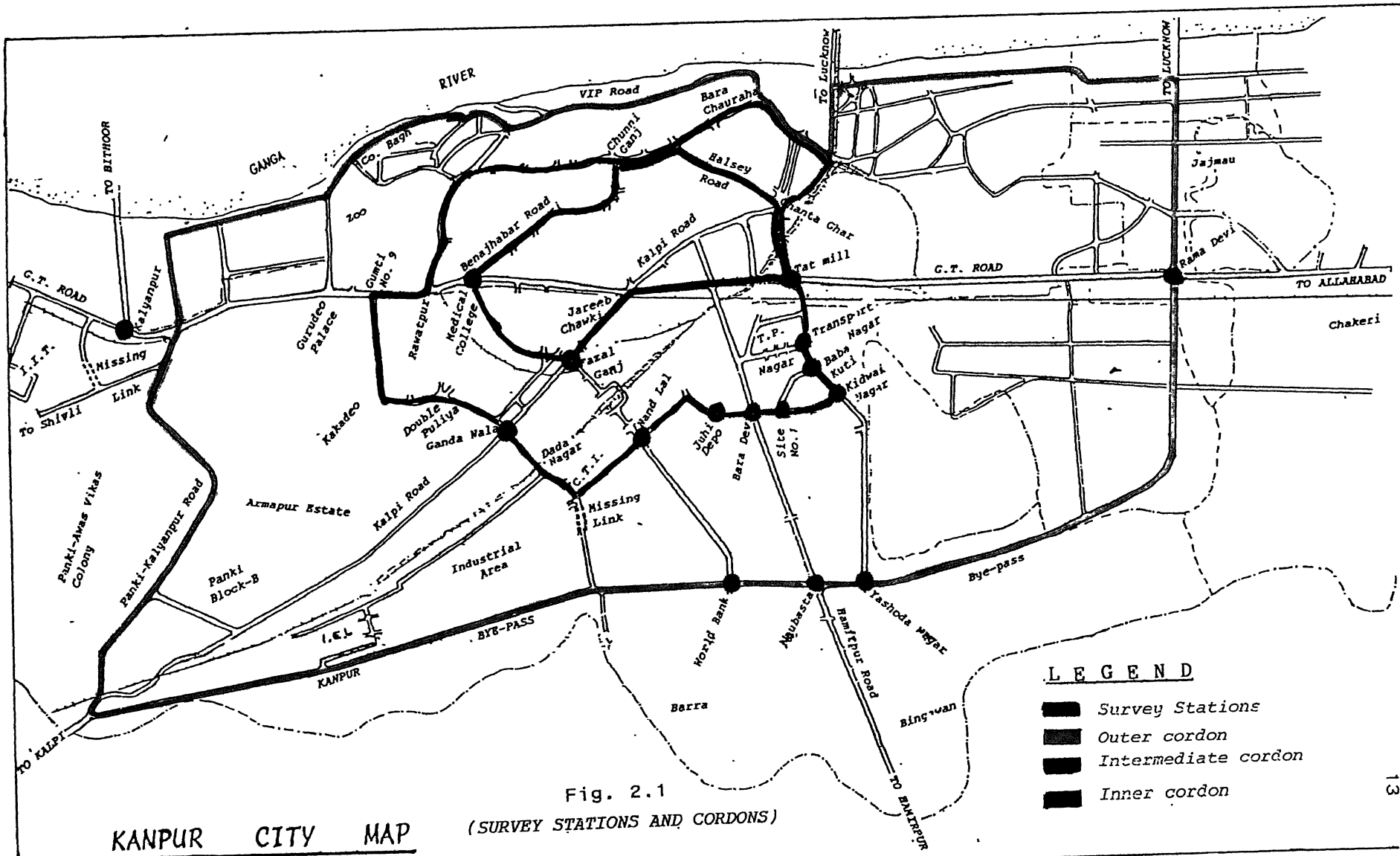


Fig. 2.1

KANPUR CITY MAP (SURVEY STATIONS AND CORDONS)

-Site No. 1 Intersection

-Kidwai Nagar Intersection

-Baba Kuti Intersection

-Transport Nagar Intersection and

-Tat Mill Intersection fall on intermediate cordon of the city.

Intersections placed on outer cordon, mainly deal with the heavy commercial vehicles which enter and exit from the city. The volumetric survey gives the feel of traffic load for inter-city goods movement. Similarly, Intersections placed on intermediate cordon deal with the heavy commercial vehicles mixed with light commercial and non-commercial vehicles. The volumetric survey at above spots gives an idea about intra-city goods movement. Out of above sixteen intersections, intersection like Bara Devi, Site No.1, Kidwai Nagar, Baba Kuti, Transport Nagar and Tat Mill fall on the outer periphery of Transport Nagar area and reveal the traffic load and circulation of commercial vehicles causing problems and its effect due to day to day Transport Nagar business.

The road inventory of the intersections and other characteristics for the sixteen intersections identified for survey was prepared in detail. These characteristics are presented in Table 2.4.

2.3.2 TRAFFIC VOLUME SURVEY ON INTERSECTIONS

It is planned to study the traffic flow pattern on all the sixteen intersections as identified earlier. The survey was planned for four hours duration each for morning and evening peak

TABLE 2.4

INTERSECTIONS SURVEYED AND THEIR CHARACTERISTICS

Sl. No.	Name of Intersection	No.of Arms	Description of Arms	Type of Junction
1	Rama Devi	Four	Toward YasodaNagar Xing Toward Allahabad Toward Jajmau Xing Toward Tat Mill Xing	- Central Rotary - Channelised but unsignalised
2	Yashoda Nagar	Four	Toward Naubasta Xing Toward 'Y'Block Xing Toward Ramadevi Xing Toward KidwaiNagar Xing	- Unsignalised - No Provision of channelisers.
3	Naubasta	Four	Toward World Bank Xing Toward Hamirpur Toward YashodaNagar Xing Toward Bara Devi Xing	- Unsignalised. - Provisions for channelisers & signal.
4	World Bank Colony	Four	Toward Bhauti Toward Barra Colony Toward Naubasta Xing Toward Parag Dairy	- Simple - Unsignalised - No provision of channeliser
5	Ganda Nala	Four	Toward Vijay Nagar Toward Panki Toward C.T.I Xing Toward Fazalganj Xing	- Unsignalised - Central Rotary
6	Kalyanpur	Four	Toward I.I.T. Toward Panki Toward Rawatpur Xing Toward Bithoor	- Unsignalised - Segregated
7	Medical College	Four	Toward Medical College Toward Rawatpur Xing Toward Eye Hospital Toward Coco Cola Xing	- Central Rotary - Channelised but unsignalised
8	Fazal Ganj	Four	Toward Jareeb Chawki Toward Mariumpur Xing Toward Ganda Nala Xing Toward Govind Nagar	- Signalised - Channelised

Contd.

Sl. No.	Name of Intersection	No.of Arms	Description of Arms	Type of Junction
9	Nand Lal	Four	Toward Juhi Depo Xing Toward Parag Dairy Toward C.T.I. Xing Toward Chawala Market	- Signalised
10	Juhi Depo	Four	Toward Baradevi Xing Toward Saket Nagar Toward Nand Lal Xing Toward Ash Mandi	- Unsignalised - Simple with speed breakers on all sides.
11	Bara Devi	Four	Toward Site No.1 Xing Toward Naubasta Xing Toward Juhi Depo Xing Toward Afim Kothi Xing	- Unsignalised - Channelised. - Provisions for signals.
12	Site No.1	Four	Toward Kidwai Nagar Xing Toward Mikkey House Toward Bara Devi Xing Toward Baba Kuti Xing	- Unsignalised - Channelised - Provision for signal.
13	Kidwai Nagar	Four	Toward Babupurwa Colony Toward YashodaNagar Xing Toward Site No.1 Xing Toward TransportNagar	- Unsignalised - Channelised - Provision for signal
14	Transport Nagar	Four	Toward Bagahi Toward Kidwai Nagar Xing Toward Juhi Canal Xing Toward Tatmill Xing	- Unsignalised - Central Rotary
15	Baba Kuti	Four	Toward Bagahi Toward Transport Nagar Toward site No.1 Xing Toward Kidwai Nagar Xing	- Unsignalised - Simple Xing
16	Tat Mill	Four	Toward Ramadevi Xing Toward AfimKothi Xing Toward Transport Nagar Toward Ghantaghar Xing	- Signalised - Channelised.

period. The volumes were recorded from 8.00 A.M. to 12.00 Noon in the morning and from 5.00 P.M. to 9.00 P.M. in the evening. These periods cover the morning and the evening peaks of a working day. Some of the intersections do not reveal full capacity and traffic load in the evening peak due to shopping activities and traffic enforcement. So, for our analysis purposes, morning four hourly traffic volume count has been taken into consideration.

The traffic volumes were recorded on all the arms of the intersection and for all turning movements. The counts were made in intervals of half-an-hour. The survey was carried out for all types of goods and passenger vehicles (fast and slow). The analysis of this study is done only for the goods traffic as per the scope of this study.

2.4. PRELIMINARY ANALYSIS OF TRAFFIC FLOW DATA

The observed traffic volume data on sixteen intersections was analysed to study the flow patterns for goods traffic. The peak period turning flows in all directions are shown in Figures 2.2 to 2.17. It is observed that the goods traffic is very high at some of the intersections, creating problems for the total traffic flow. Study of these data indicate that the following four intersections have very heavy flows. The flow characteristics on these four critical intersections are presented below :-

- Naubasta intersection is having heavy left turning movement from Hamirpur side to Bye pass and from Yashoda Nagar side to Hamirpur side. Similarly there is a heavy right turning movement from Bye pass to Hamirpur side. The above turnings, wi

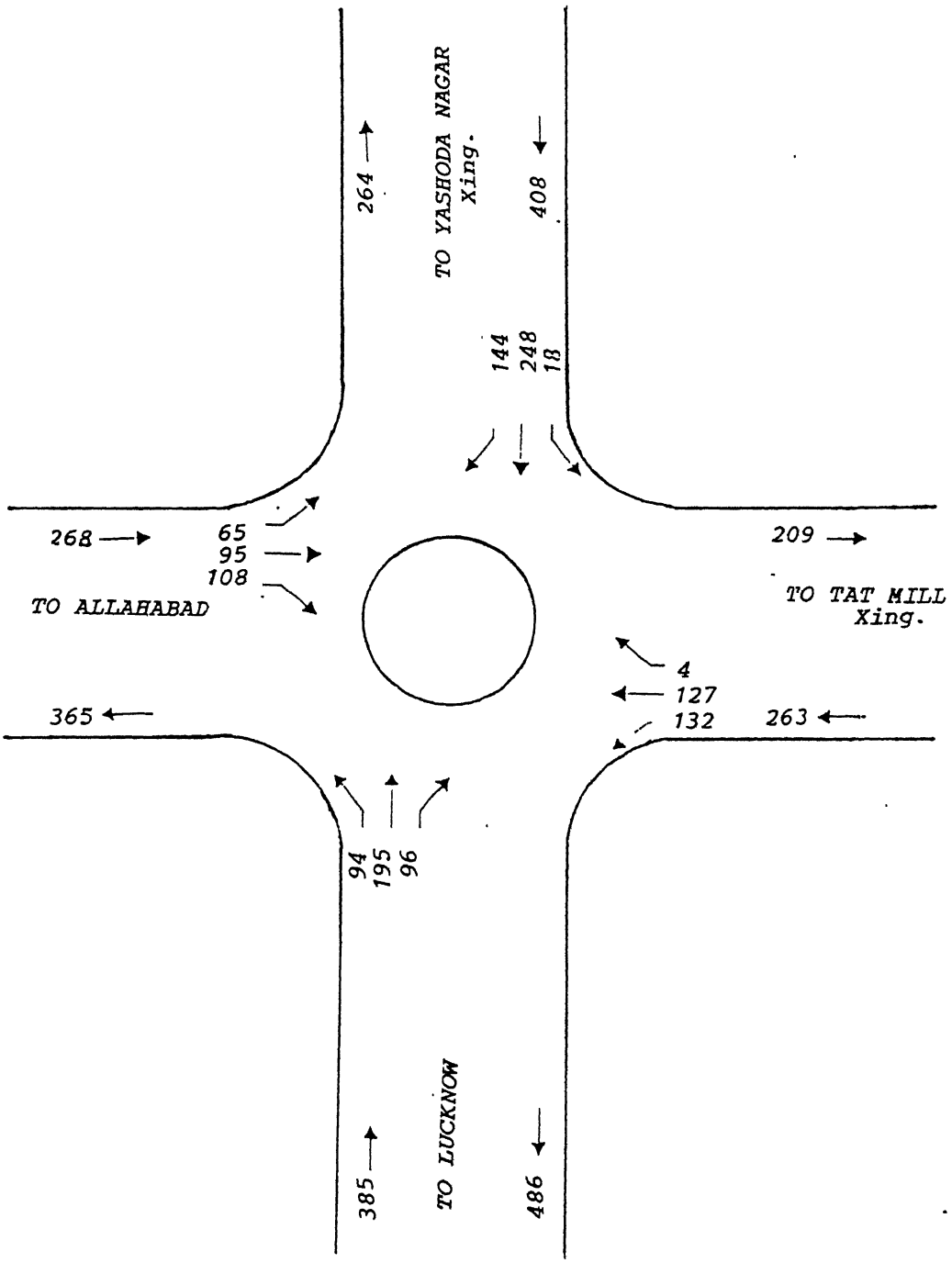


FIGURE 2.2 FOUR HOURLY TRUCK VOLUME AT RAMADEVI INTERSECTION

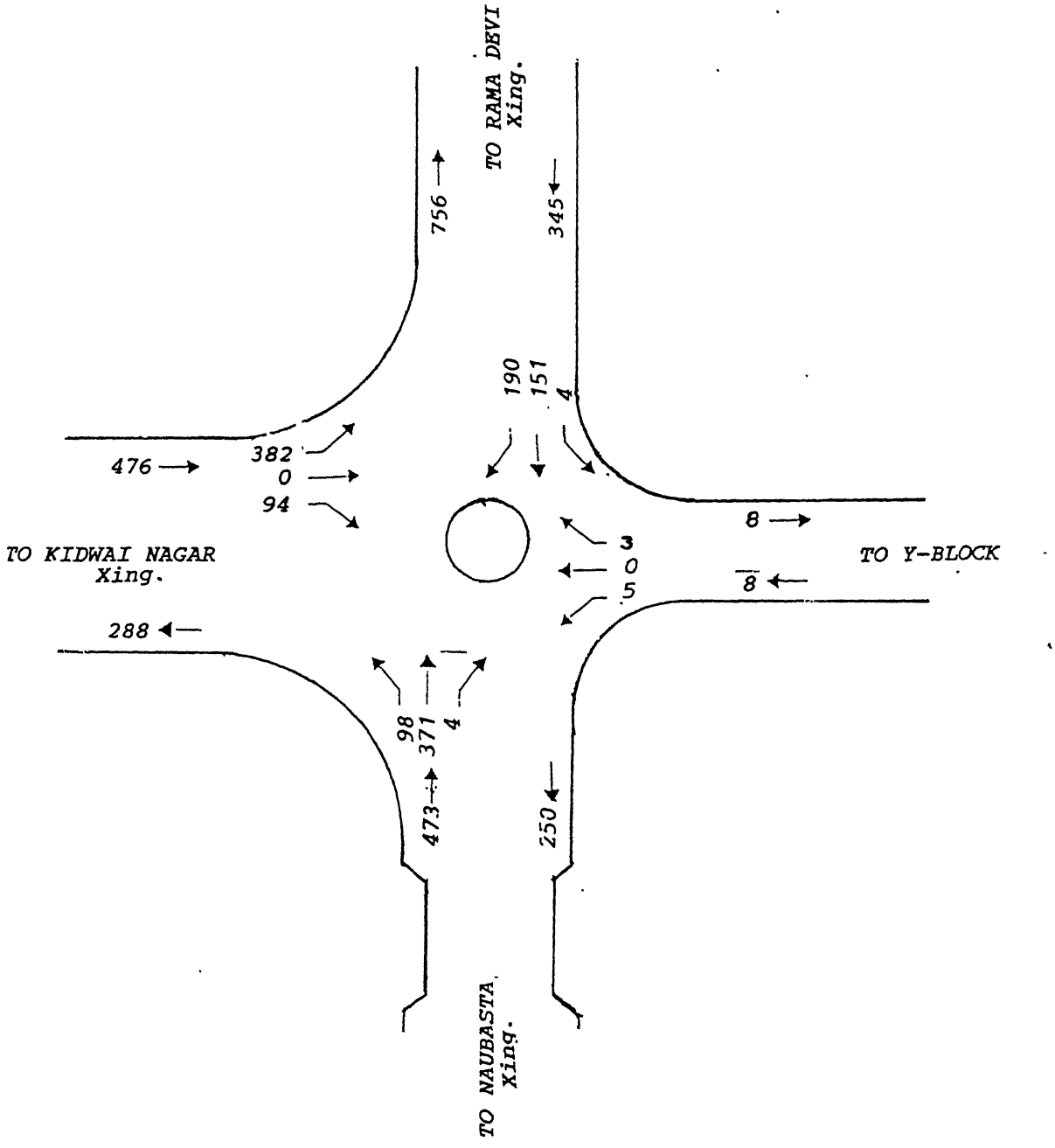


FIGURE 2.3 FOUR HOURLY TRUCK VOLUME AT YASHODA NAGAR INTERSECTIC

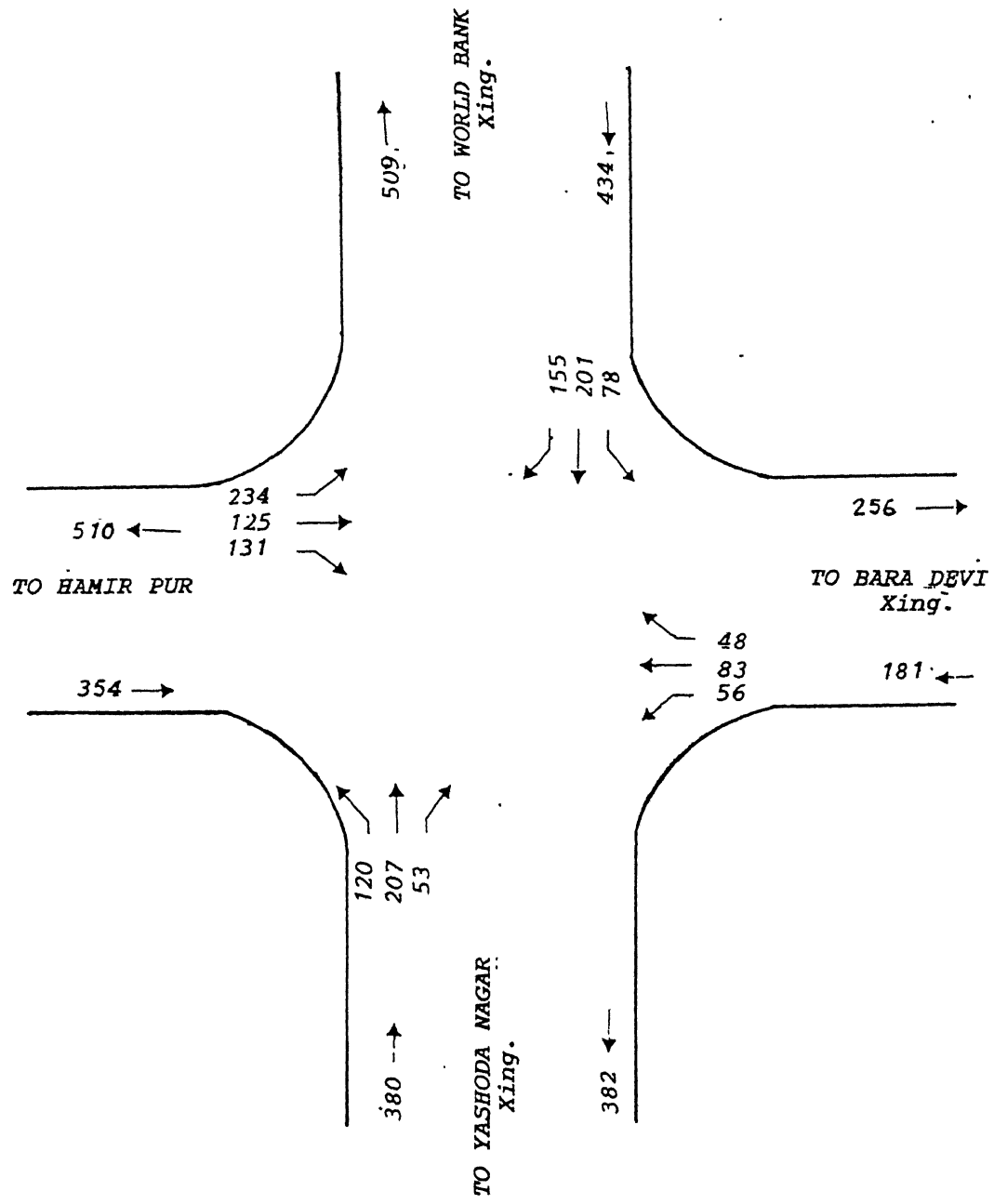


FIGURE 2.4 FOUR HOURLY TRUCK VOLUME AT NAUBASTA INTERSECTION

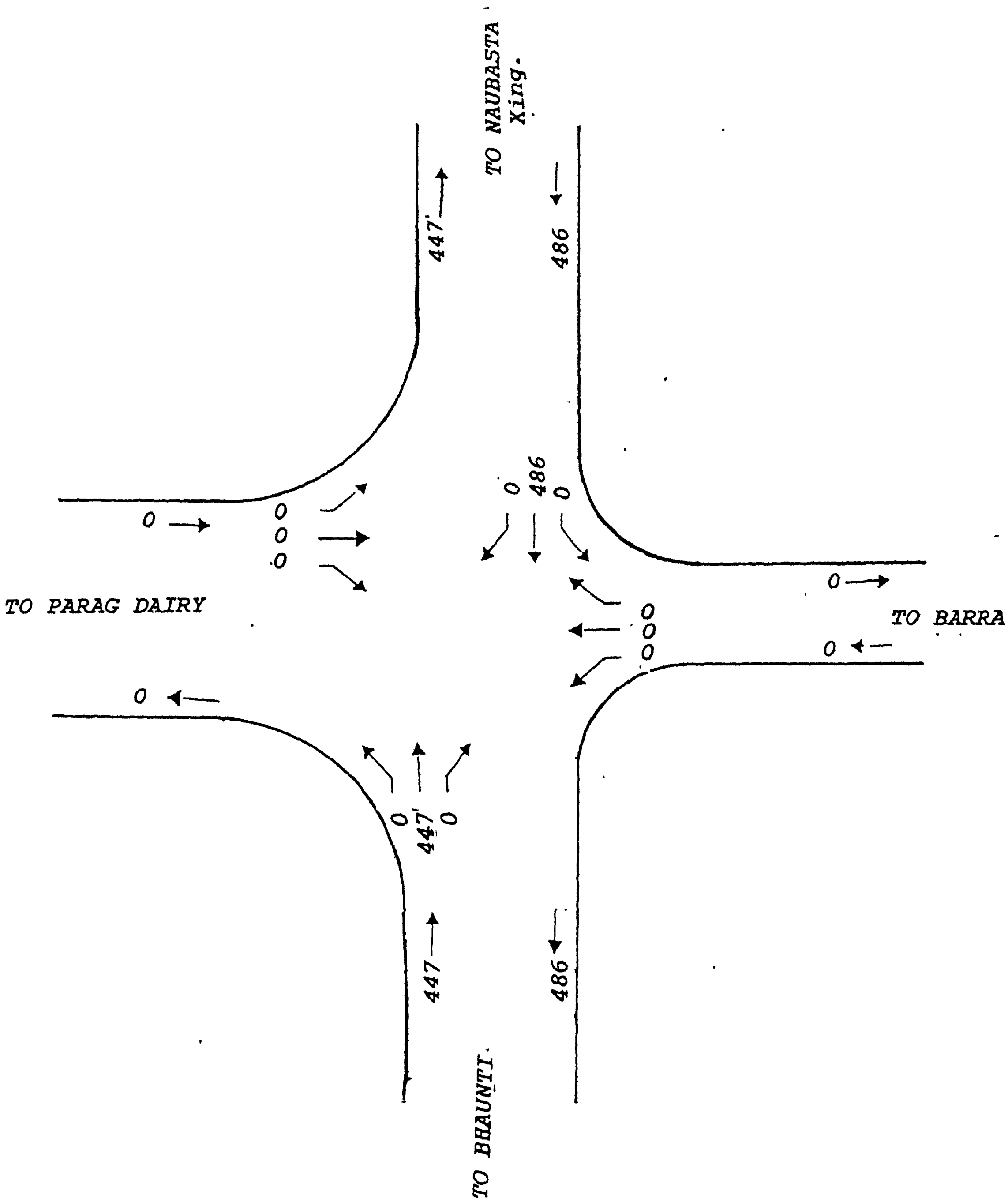


FIGURE 2.5 FOUR HOURLY TRUCK VOLUME AT WORLD BANK INTERSECTION

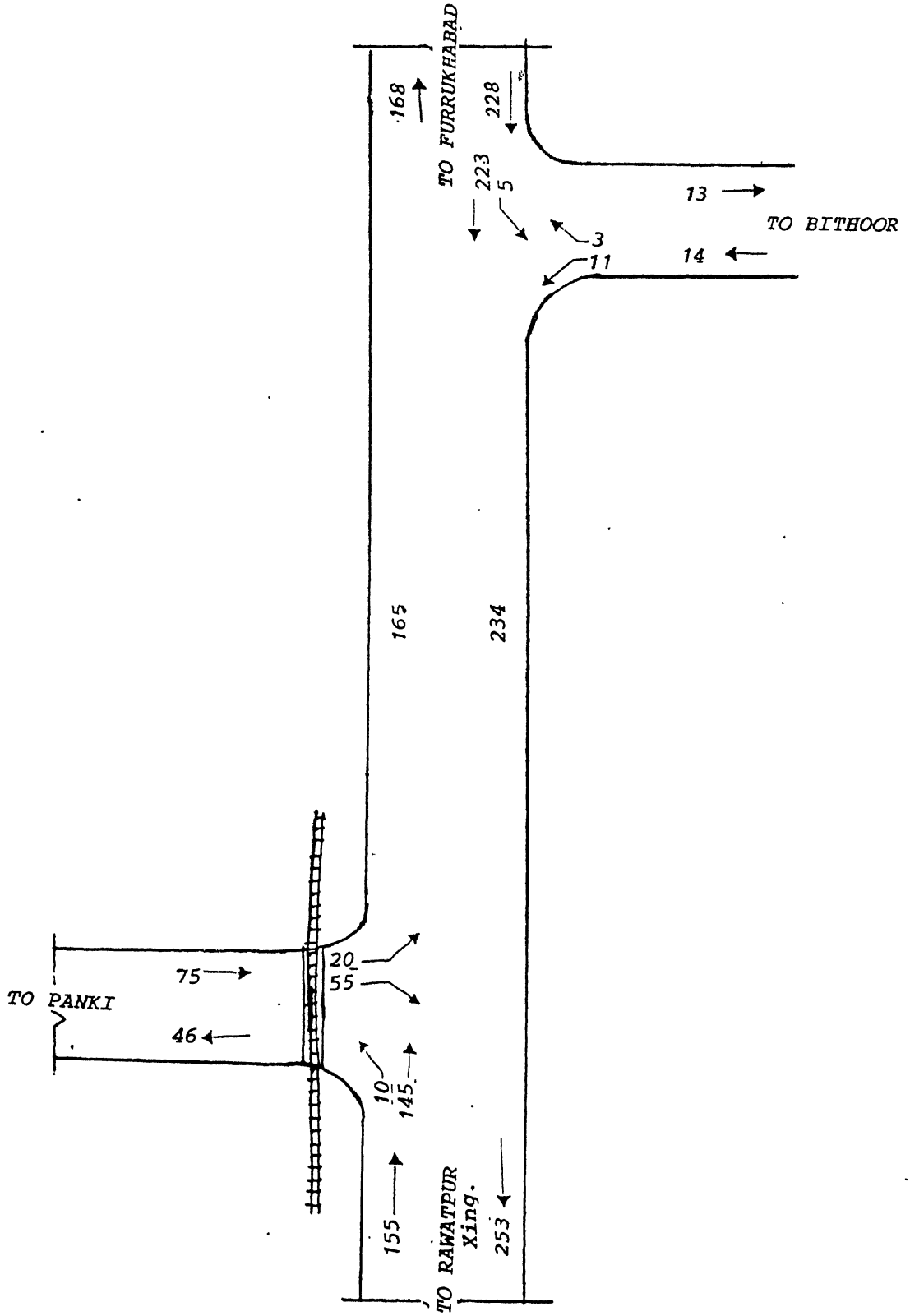


FIGURE 2.6 FOUR HOURLY TRUCK VOLUME AT KALYANPUR INTERSECTION

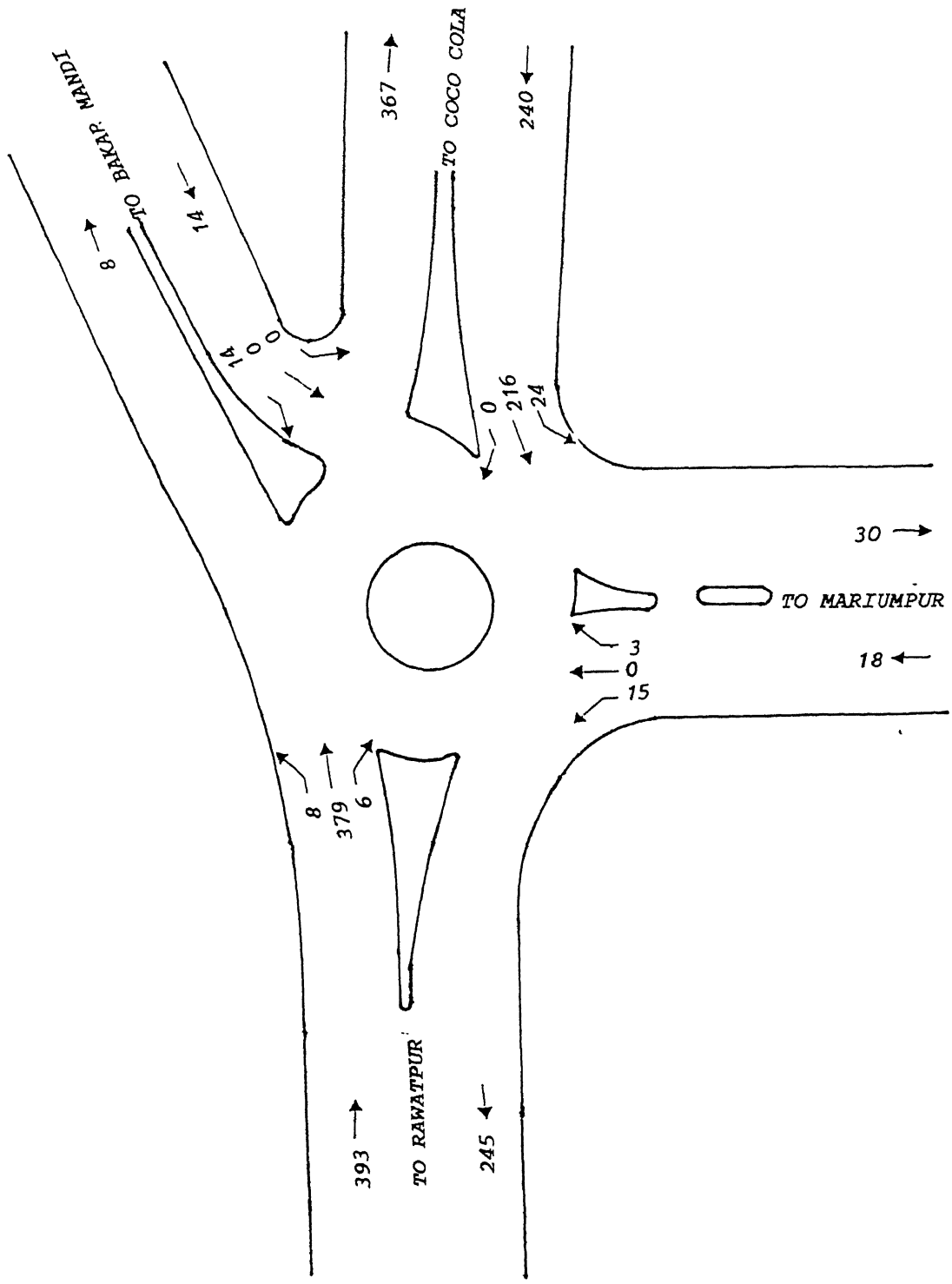


FIGURE 2.7 FOUR HOURLY TRUCK VOLUME AT MEDICAL COLLEGE INTERSECT

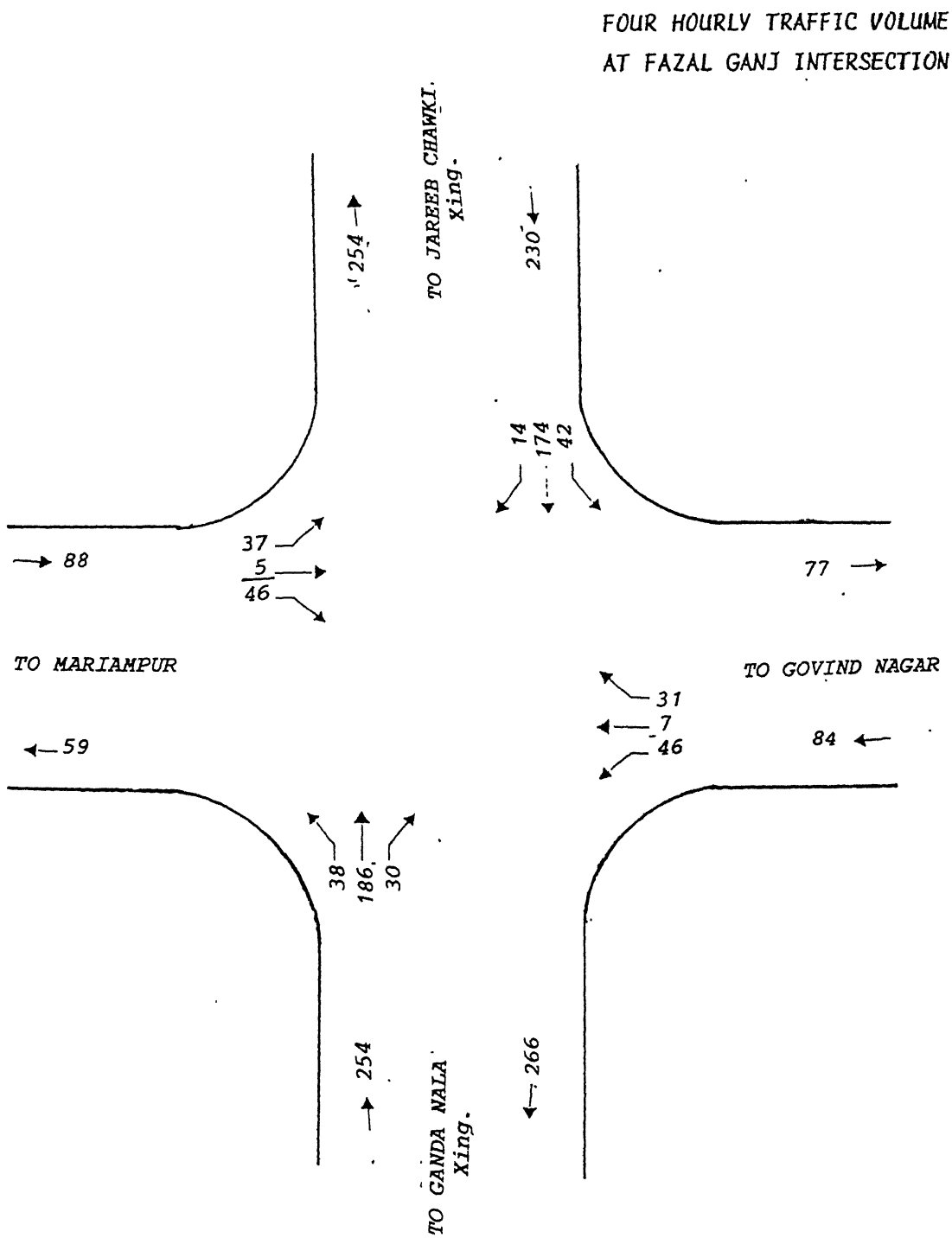


FIGURE 2.8 FOUR HOURLY TRUCK VOLUME AT FAZAL GANJ INTERSECTION

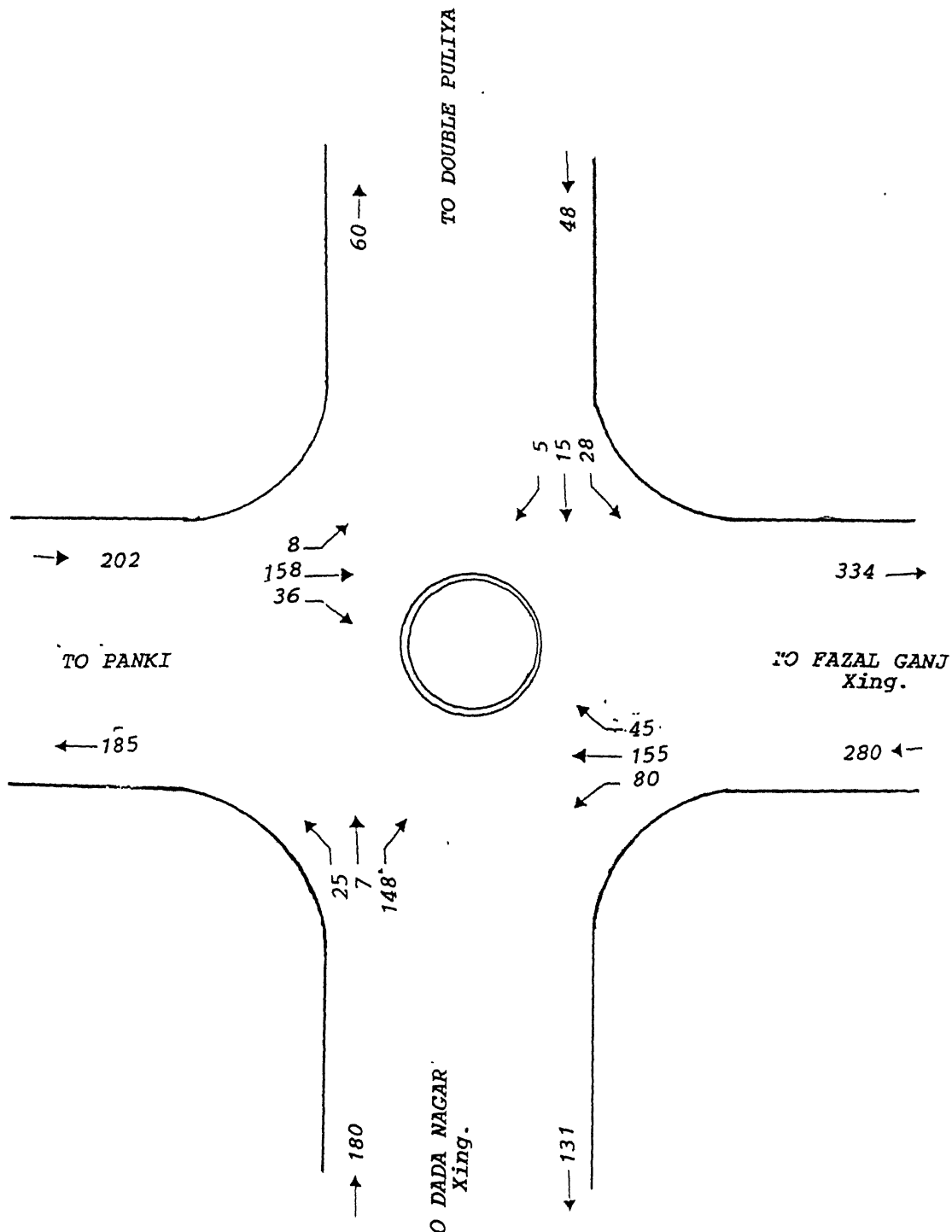


FIGURE 2.9 FOUR HOURLY TRUCK VOLUME AT GANDA NALA INTERSECTION

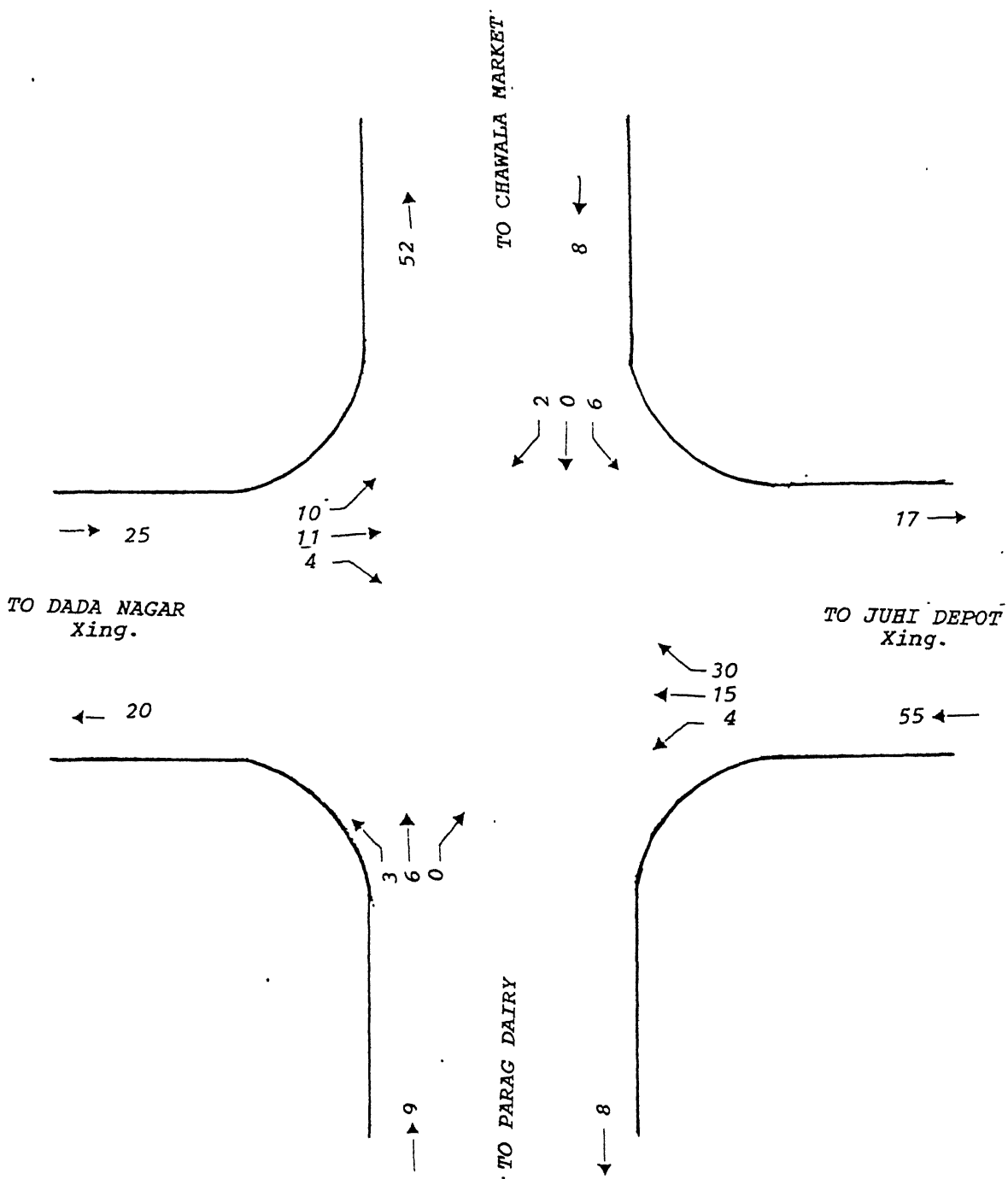


FIGURE 2.10 FOUR HOURLY TRUCK VOLUME AT NAND LAL INTERSECTION

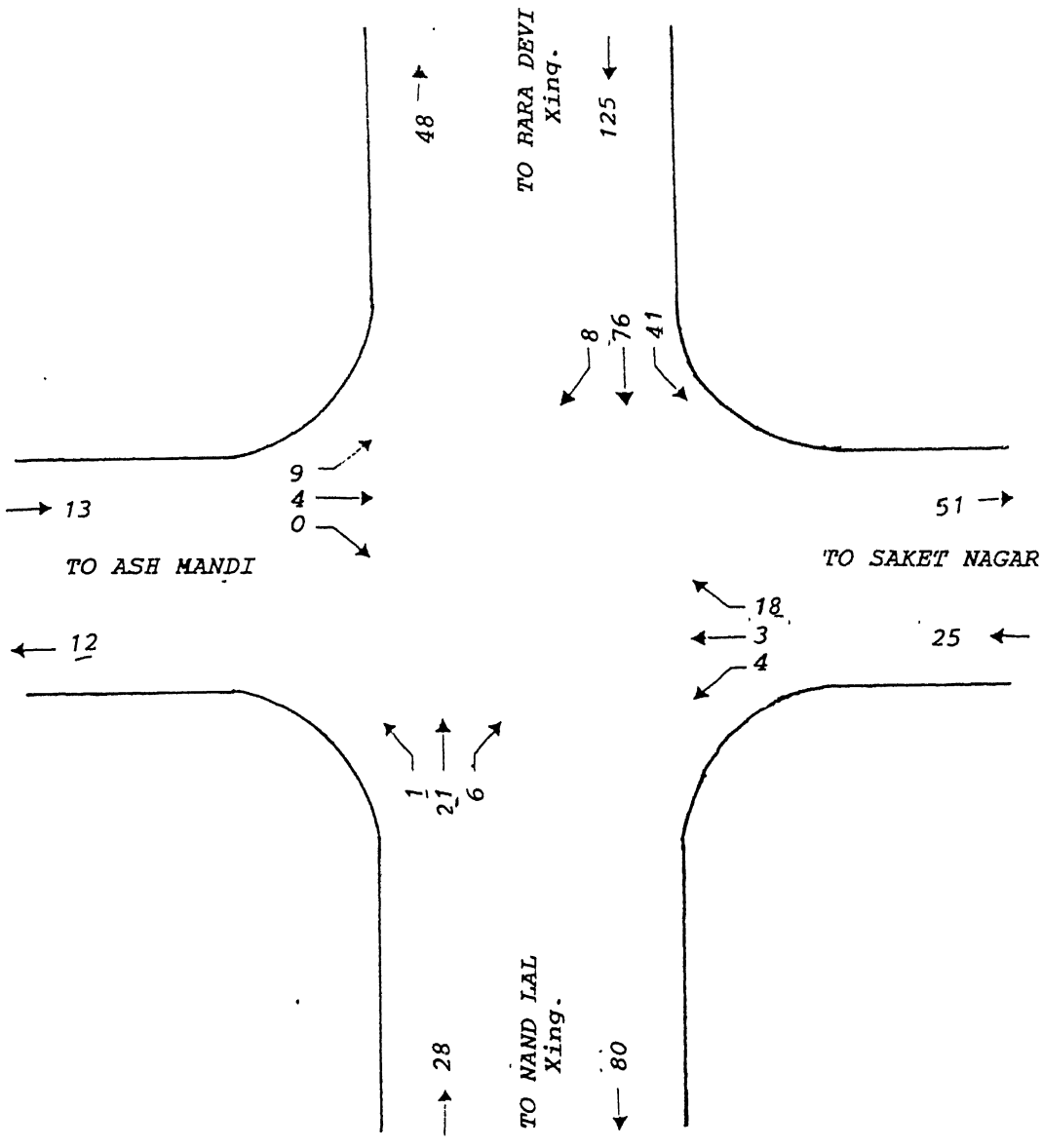


FIGURE 2.11 FOUR HOURLY TRUCK VOLUME AT JUHI DEPOT INTERSECTION

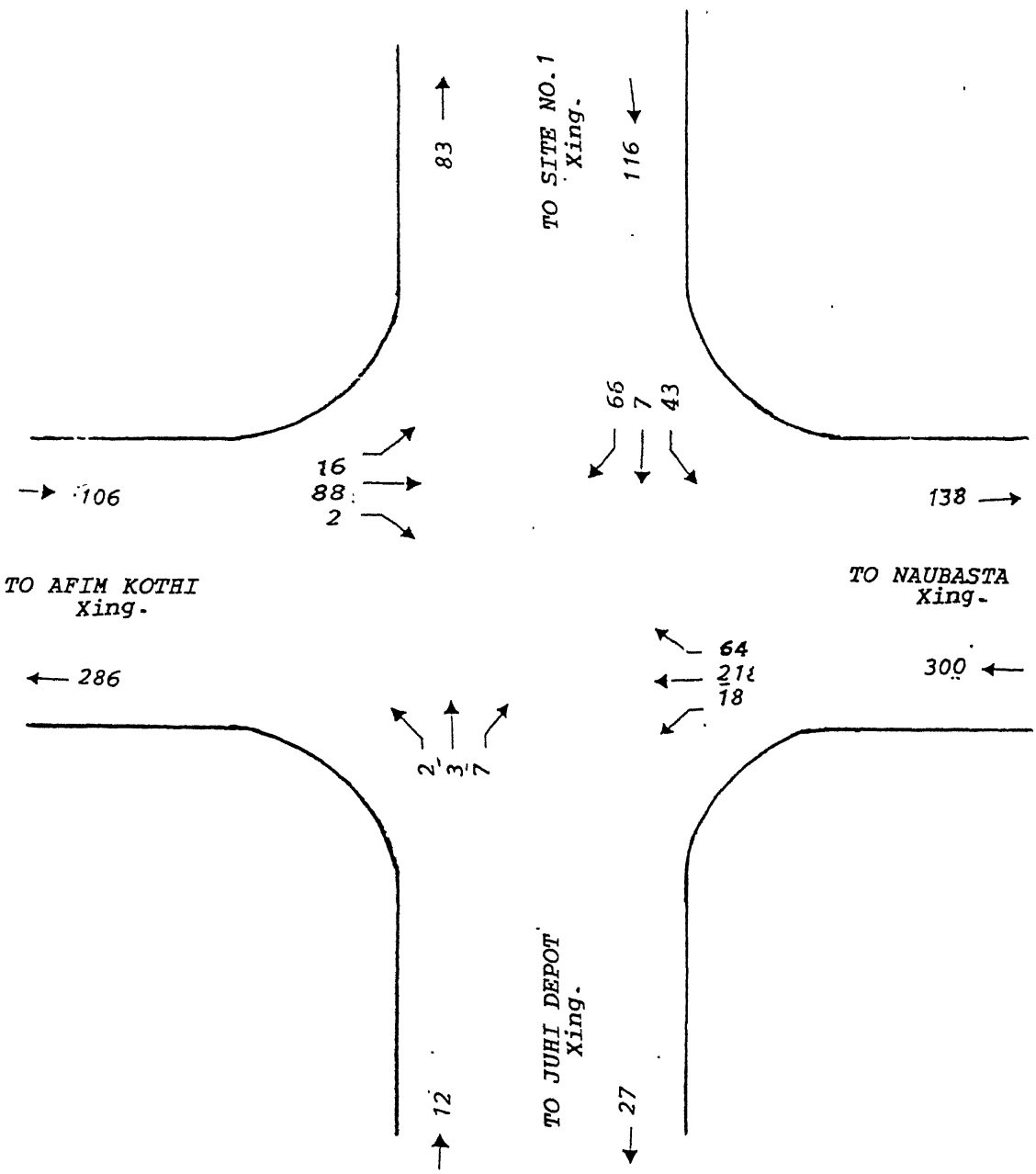


FIGURE 2.12 FOUR HOURLY TRUCK VOLUME AT BARA DEVI INTERSECTION

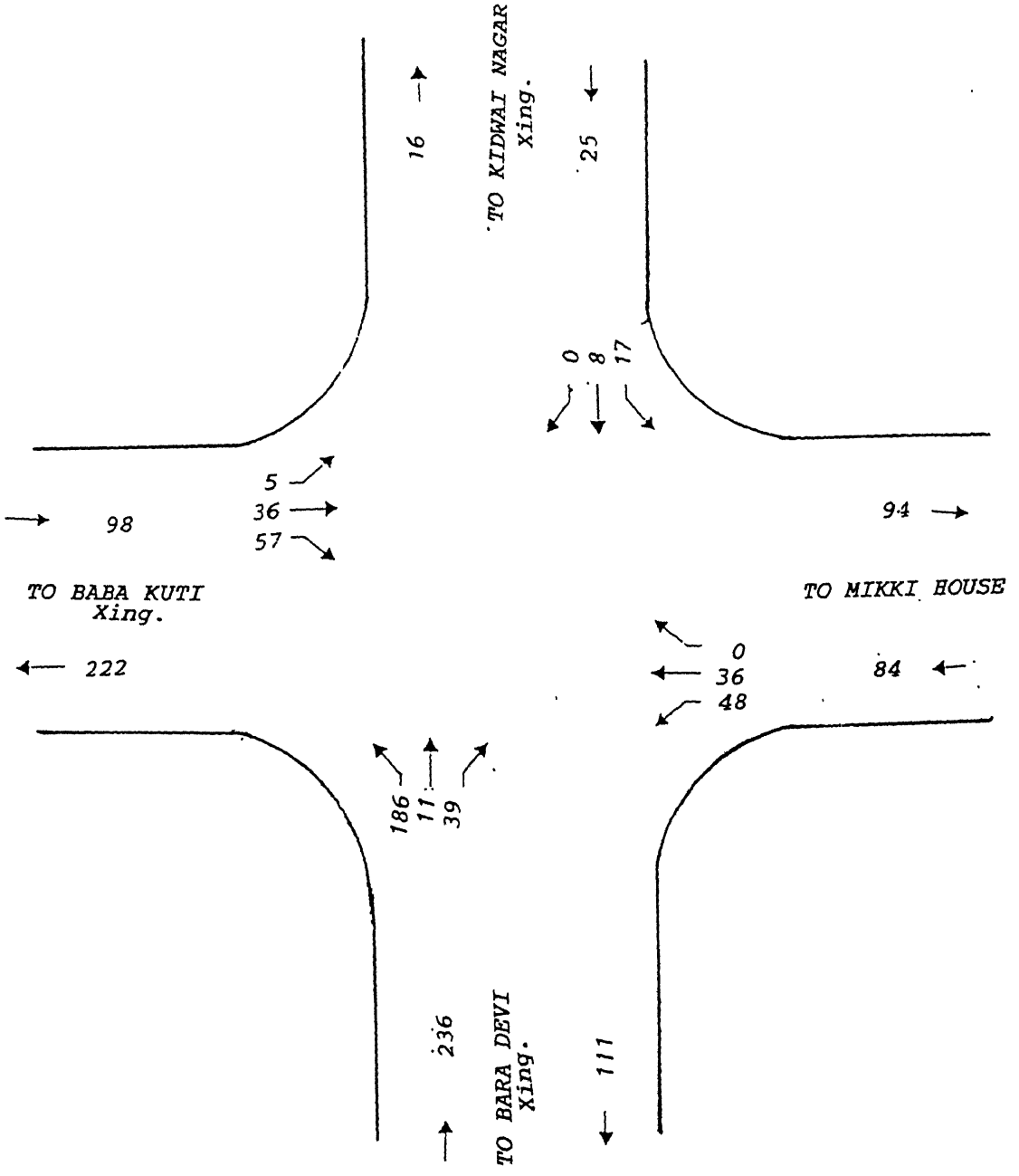
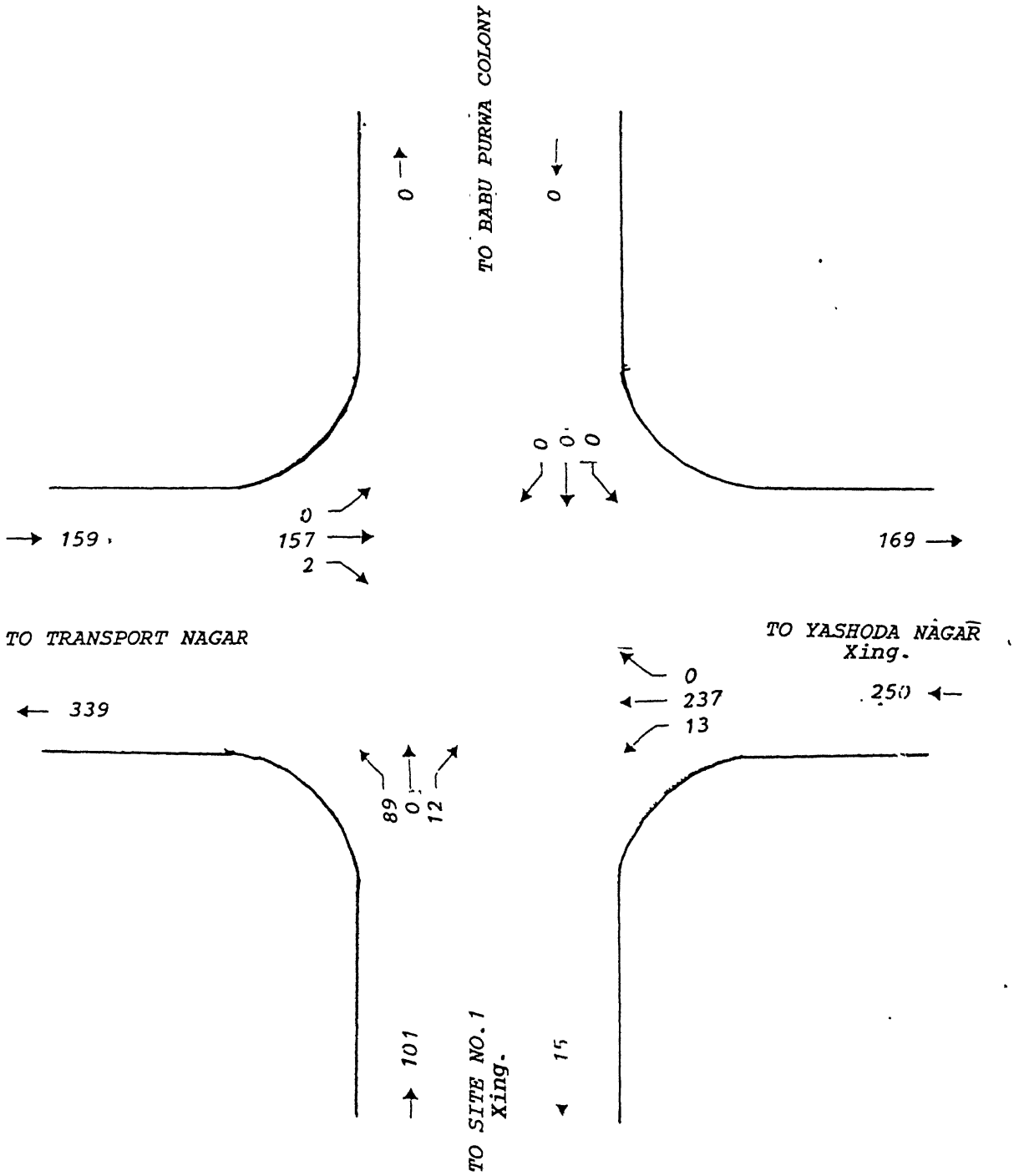


FIGURE 2.13 FOUR HOURLY TRUCK VOLUME AT SITE NO. 1 INTERSECTION



IGURE 2.14 FOUR HOURLY TRUCK VOLUME AT KIDWAI NAGAR INTERSECTION

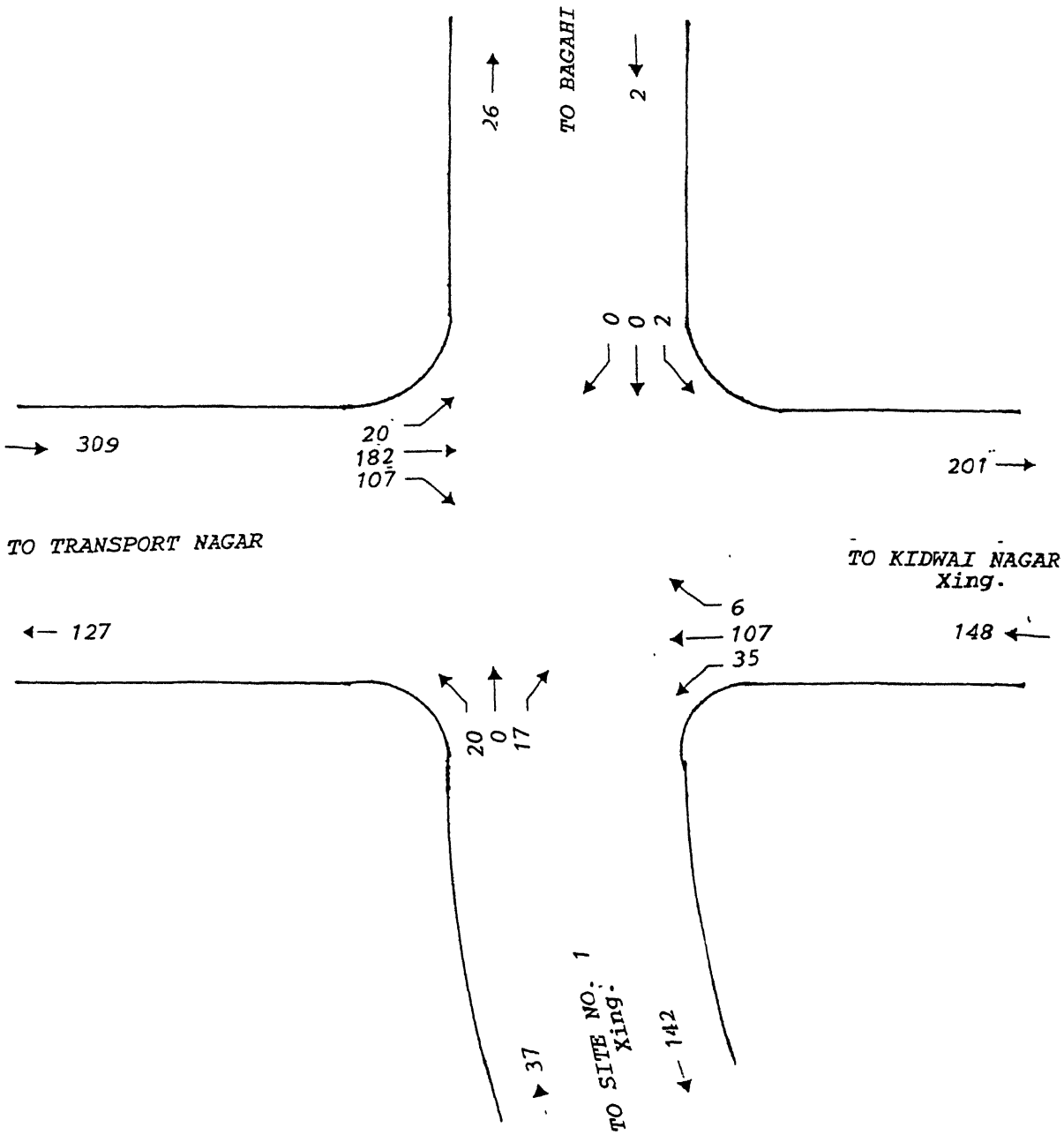


FIGURE 2.15 FOUR HOURLY TRUCK VOLUME AT BABA KUTI INTERSECTION

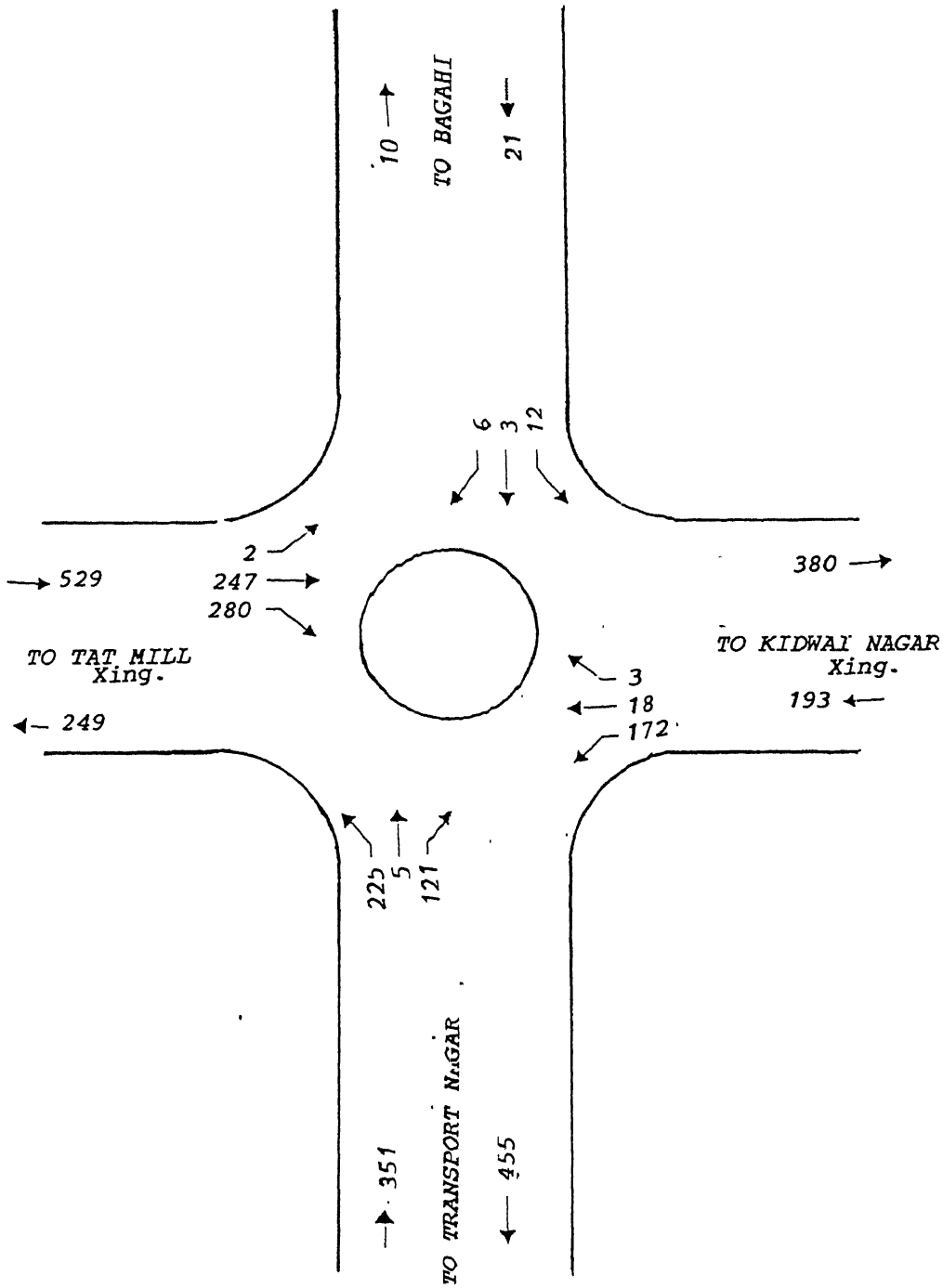


FIGURE 2.16 FOUR HOURLY TRUCK VOLUME AT TRANSPORT NAGAR INTERSECTION

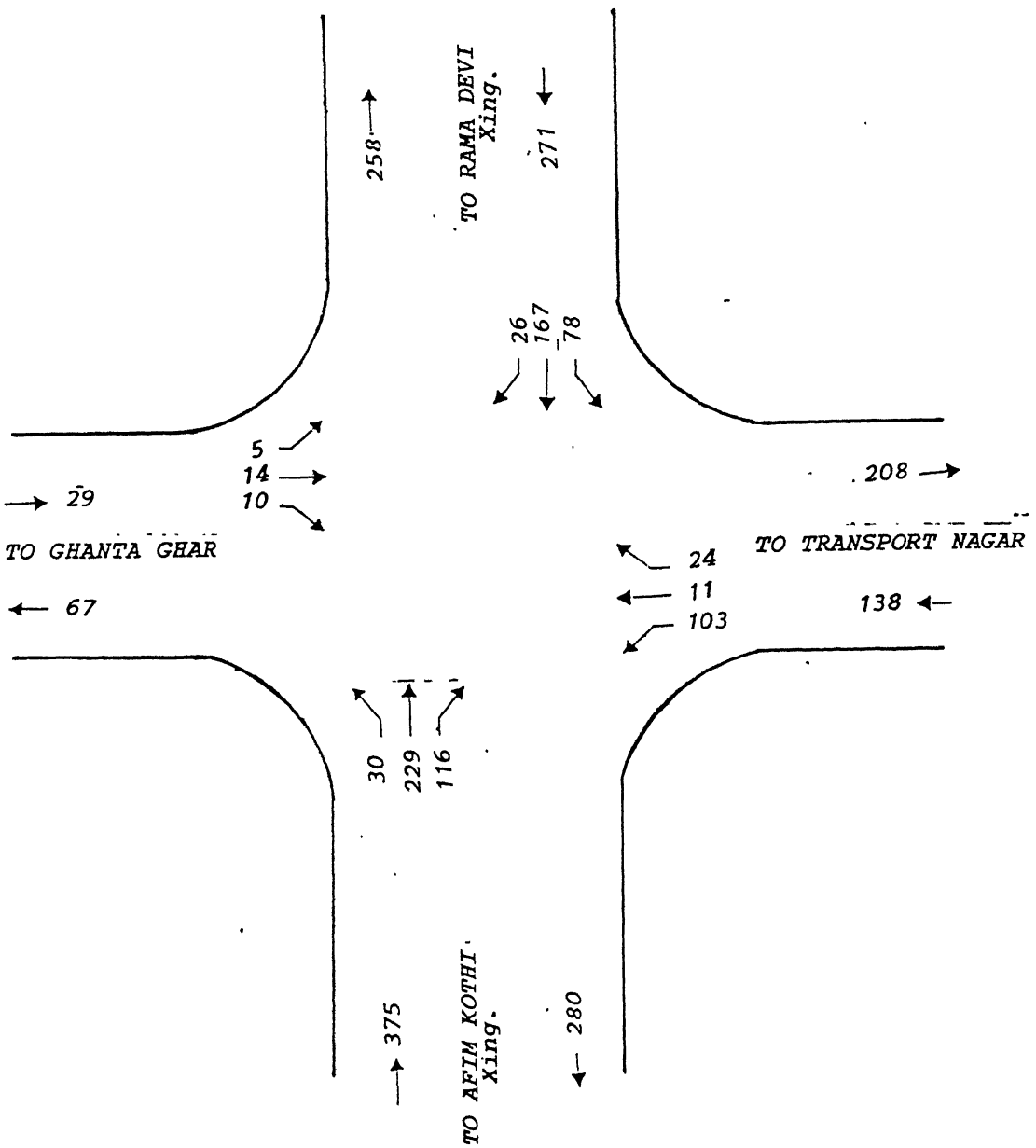


FIGURE 2.17 FOUR HOURLY TRUCK VOLUME AT TAT MILL INTERSECTION

out any proper guidance through signals and traffic police, create mess at the intersection.

- Yashoda Nagar intersection is presenting a very heavy left and right turnings from bye pass towards Kidwai Nagar and Transport Nagar intersection. This movement is in between 60 to 90 percent of the total truck volume at this intersection. Therefore Yashoda Nagar intersection also needs improvements for proper guidance of the traffic.

- Transport Nagar intersection shows a tremendous left turn from inside the Transport Nagar towards Tat Mill intersection and from Kidwai Nagar side to Transport Nagar area. There is around 70 to 80 percent of the total inflow in that direction. Similarly, there is a substantial right turning movement from G.T. Road side towards Transport Nagar area.

- Tat Mill intersection possesses heavy. left turning movement from Transport Nagar side towards Afim Kothi intersection and right turning from Afim Kothi intersection towards Transport Nagar intersection.

Study of the flow on various arms of the intersections indicate that the following road stretches are in critical state with regard to the movement of the goods traffic. The flow on some of the stretches is very heavy causing congestion. Some of the critical stretches as identified are given below :-

- Stretch between Tat Mill intersection to Transport Nagar intersection is only 2 to 3 lane wide and there is an over bridge between them. The road condition is very bad and untreated shoulders of the bridge approaches, causing road accidents.

- Stretch between Yashoda Nagar intersection to Naubasta intersection is on Kanpur bye pass. This is also only two lane wide. Because of the straight road stretch, the speed of the trucks is very high. This stretch is causing second highest road accidents because of bad light, lack of proper road signs and insufficient road width. (IRC, 1979)

2.4.1. ESTIMATION OF PEAK HOURLY FLOW

The observed volumes, recorded in half-an-hour interval are analysed, to determine the peak hourly flow and the peak hour factor (P.H.F.). Data show that within the peak period of four hours, the peak hour flow is different for different intersections. The peak hour time depends on the location of the intersections and the type of goods carried by the vehicles. As an example the peak hour flow at Naubasta intersection is in between 9.00 A.M. to 10.00 A.M. while at Yashoda Nagar intersection, it is in between 9.30 A.M. to 10.30 A.M. Similarly for Kalyanpur intersection, it is in between 11.00 A.M. to 12.00 Noon. At the above three major intersections it is desirable to design signal timings and thus requires the estimation of peak hour factor (P.H.F.).(Hutchinson B.G.) The P.H.F., based on the traffic volumes recorded for half-an-hour were calculated and there values are found to be for :-

Naubata intersection	0.833
Yashoda Nagar intersection	0.831
Kalyanpur intersection	0.828

The above values of the peak hour factor indicate that there are significant peak within the peak hour flow. These

factors for the total traffic must be taken into account in designing the signal timings.

2.5 STUDY OF GROWTH PATTERN FOR GOODS TRAFFIC

Kanpur is a major industrial city of the northern India. Commercial trade is coming in and going out from five main arterials eg from Lucknow, Gorakhpur side (NH-25)

Allahabad, Varanasi side (NH-2)

Hamirpur, Jhansi side (SH-17)

Kalpi, Delhi side (NH-25)

Agra, Farrukhabad, Delhi side (SH-22)

The intersections involved in catering the traffic from above mentioned places are mainly :-

Rama Devi/ Tat Mill/ Yashoda Nagar intersection,

Naubasta intersection,

Ganda Nala / Fazalganj intersection and

Kalyanpur intersection

These intersections are mainly influenced by the through traffic while the intersections like

Medical College,

Bara Devi,

Site No.1,

Kidwai Nagar and

Transport Nagar are influenced by the through traffic as well as by local goods movement caused due to day to day activities of local industries and their supplies.

The observed traffic flows on the various intersections were compared with the past data available for the year 1982-83.

(KMC, 1983). Taking the traffic flow for the year 1982-83 as a base year, the annual growth rate over the last decade is determined and presented in Table 2.5. Results for the growth rate show that there are significant variation among the intersections. The growth rate lie between 8.91 to 20.89 percent. The variations can be attributed to the locations of the intersection and its environment. These are studied, in detail, for the various intersections and are discussed in the following paras.

- At Kalyanpur intersection the growth rate (compound) is only 8.91 percent, while at Tat Mill, Yashoda Nagar, Naubasta and Fazalganj intersection it is around two times than that of at Kalyanpur intersection. The reason being that there are number of intersections, a narrow over-bridge and a railway crossing exists on G.T. Road and on the other hand lesser number of crossings and smoother traffic flow on bye pass road.

- This is also true in the case of Tat Mill and Yashoda Nagar intersections. While moving from Ramadevi intersection to Transport Nagar, drivers want to ply on bye pass and take a right turn from Yashoda Nagar intersection instead of moving on G.T. Road and taking left turn from Tat Mill intersection.

- The intersections, which are within the intermediate cordon and are affected by the local commercial vehicles, we find that the growth rate for goods traffic at Medical College Intersection is only 11.24 percent. It is due to the fact that Kalyanpur and Tat Mill intersections show a less increase in goods vehicles and drivers want to avoid the

TABLE 2.5

AVERAGE ANNUAL TRUCK GROWTH RATE FOR DIFFERENT INTERSECTIONS

S.No. LOCATION	1982 - 83 UP	DN	TOTAL	1992 - 93 UP	DN	TOTAL	Total Growth	% Yearly growth
1. KALYANPUR XING								
G.T. Road (1)	580	618	1198	1008	1368	2376		
" " (2)	552	402	954	1518	930	2448		
Bithoor Rd. (3)	18	6	24	78	84	162		
Panki Rd. (4)	75	181	256	276	450	726		
			2432			5712	3280	8.91
2. MEDICAL COLLEGE XING								
G.T. Road (1)	784	815	1599	1470	2358	3828		
" " (2)	508	523	1031	2202	1440	3642		
Benajhabar (3)	16	8	24	48	84	132		
Eye Hosp.Rd.(4)	26	38	64	180	108	288		
			2718			7890	5172	11.24
3. FAZAL GANJ XING								
Kalpi Rd. (1)	272	358	630	1596	1524	3120		
" " (2)	526	405	931	1524	1380	2904		
Govind Nagar(3)	68	82	150	462	504	966		
Kabari Market(4)	87	118	205	354	528	882		
			1916			7872	5956	15.18
4. NAUBASTA XING								
Hamirpur Rd. (1)	305	578	883	2124	3060	5184		
" " (2)	206	150	356	1536	1086	2622		
Bye Pass (3)	948	712	1660	3054	2604	5658		
" " (4)	406	398	804	2292	2280	4572		
			3703			18036	14333	17.15
5. YASODA NAGAR XING								
Bye pass (1)	308	514	822	1500	2838	4338		
" " (2)	678	384	1062	4536	2070	6606		
To KidwaiNagar (3)	196	265	441	1728	2856	4584		
To Yashoda Nagar(4)	6	11	17	48	48	96		
			2342			15624	13282	20.89
6. BARA DEVI XING								
Hamirpur Rd. (1)	266	342	698	828	1800	2628		
" " (2)	306	214	520	1716	636	2352		
Govind Nagar (3)	48	35	83	162	72	234		
Site No. 1 (4)	187	216	403	498	696	1194		
			1614			6408	4596	14.78

S.No. LOCATION	1982 - 83 UP	DN	TOTAL	1992 - 93 UP	DN	TOTAL	Total Growth	% Yearly growth
7. SITE NO.1 XING								
Bara Devi (1)	174	278	452	666	1416	2082		
Kidwai Nagar (2)	22	18	40	96	150	246		
Baba Kuti (3)	305	187	492	1332	588	1920		
Mikky House (4)	48	66	114	564	504	1068		
			1098			5316	4218	17.08
8. KIDWAI NAGAR XING								
Site No. 1 (1)	27	48	75	90	606	696		
Babupurwa (2)	0	0	0	0	0	0		
Yashoda Nagar (3)	271	367	638	1014	1500	2514		
Transport Nagar (4)	317	196	513	2034	954	2988		
			1226			6198	4972	17.59
9. TRANSPORT NAGAR XING								
Kidwai Nagar Xing (1)	598	412	1010	2280	1158	3438		
Tatmill (2)	372	648	1030	1494	3174	4668		
Bagahi (3)	12	10	22	7	126	186		
Hamirpur Rd. (4)	574	475	1049	2720	2106	4826		
			3101			13118	10017	15.51
10. TATMILL XING								
G.T. Rd. (1)	518	448	1002	1548	1626	3174		
" " (2)	478	714	1192	1680	2250	3930		
Ghantaghar (3)	124	37	161	402	174	576		
Transport Nagar (4)	310	196	506	1248	828	2076		
			2861			9756	6895	13.05

congested stretch of the city. Similarly, if we compare intersections like Bara Devi, Site No. 1, Kidwai Nagar and Transport Nagar, we find that the rate of increase (Compound) is ranging between 14.78 to 17.59 percent, which is on higher side. It is due to the same fact that drivers move safely and smoothly on bye pass road, and want to avoid delay at railway crossings and congested road stretches. The above intersections have total influence of Yashoda Nagar and Naubasta intersection on bye pass road. Because of higher traffic growth rate at Naubasta and Yashoda Nagar intersections, above four intersections show a greater increase in truck traffic.

- The increasing trend in truck traffic, reveals the fact that the road stretches like Bara Devi - Kidwai Nagar road stretch and Tat Mill - Yashoda Nagar road stretch have been tremendously congested and problematic during the last decade. These stretches are around Transport Nagar area. It shows that if the same trend is continued, Transport Nagar area will be heading towards completely jamming and utterly confusing situation.

The high rate of growth for the goods traffic indicates that the share of the goods vehicle on the major roads is increasing due to rapid growth in the number of goods vehicles. (Refer Table 2.3).

2.6 FUTURE SCENARIO OF GOODS TRAFFIC

Results have shown that the demand for goods traffic has increased at a rapid rate in the last decade. Assuming the same growth rate, the traffic demand at various intersections for the year 2001 is forecasted and is presented

TABLE 2.6

DAILY TRUCK VOLUME AT DIFFRENT INTERSECTIONS

(PREDICTION FOR THE YEAR 2001)

S.No.	NAME OF INTERSECTION	1982-83	1992-93	Prediction for 2001
1.	Kalyanpur	1216	2856	5653
2.	Medical College	1359	3945	9250
3.	Fazal Ganj	958	3936	12192
4.	Naubasta	1852	9018	31952
5.	Yashoda Nagar	1171	7812	35635
6.	Bara Devi	807	3204	9652
7.	Site No. 1	549	2658	9384
8.	Kidwai Nagar	613	3099	11329
9.	Transport Nagar	1551	6559	20787
10.	Tat Mill	1431	4878	13014

in Table 2.6. This shows that the goods traffic at different intersections is presenting an alarming and jamming situations at mainly Naubasta, Yashoda Nagar and Transport Nagar intersections. The values mentioned in the Table 2.6, certainly will not cater the traffic by the existing capacity of the road system. Road stretches between Rama Devi - Naubasta intersection (on bye pass), Tat Mill - Yashoda Nagar intersection and Kidwai Nagar - Bara Devi intersection show a complete problematic and accident prone stretches. There will certainly be a critical situation in this part of the city in near future.

2.7 CONCLUSION

Based on the above information, we find that there is a tremendous increase in the goods traffic and subsequent commercial activities in south Kanpur region. Transport Nagar area which was earlier surrounded by purely residential colonies, has now become semi- commercial, causing a complete change in the transport scenario of this part of the city. A sizable road space is wasted due to non-traffic uses eg encroachment, shop extensions, hawkers, stray cattle and unsystematic parking etc. If this trend is continued for a long time, there will be severe traffic congestion and utter confusion on the abutting roads. There is need, therefore, of immediate redressal of the transport problem enumerated above, to ward off the impending collapse of the transport system in this part of the city.

3. STUDY OF GOODS TRAFFIC MOVEMENT IN TRANSPORT NAGAR AREA

3.1 LOCATION AND PROBLEMS OF TRANSPORT NAGAR

The Transport Nagar came into existence way back in 1960's to provide center for handling cargo traffic. It is located in the southern half of Kanpur from where the disposal of goods takes place to different parts of the city. It was originally planned on the southern out skirt, adjacent to the two National Highways ie Kanpur bye pass and G.T.Road, and one State Highway ie Hamirpur Road passing through the city. But due to the development activities mostly concentrating in south Kanpur, it has come well within the intermediate and outer cordon of the city. Secondly due to the main railway track situated very next to the Transport Nagar, its access to the C.B.D. is across the railway line through over bridges and an under pass on which traffic has far out grown the capacity.

Existing Transport Nagar consists of one major link road, working as spinal cord to this area and other link roads at right angles to this. Along and inside the Transport Nagar area, we find haphazard truck parking which leads to massive parking problems, utter confusion and jamming problems.

3.2 INVENTORY OF ROAD SYSTEM IN TRANSPORT NAGAR

Transport Nagar area is surrounded by four major roads eg Kidwai Nagar - Bara Devi road, Baba Kuti - Juhi Canal road along east-west direction and Kidwai Nagar - Tat Mill road, Bara

Devi - Juhi Canal road along north-south direction. All these roads are having 3 to 6 lane wide metalled portion and 150 ft. to 250 ft. as right of way. The road stretch inventory of the main roads and different corridors / road sides activities around and inside the Transport Nagar area is shown in Table 3.1.

Transport Nagar consists of one major road ie from Transport Nagar intersection - Juhi Canal intersection. This road is having 200 ft. as right of way, out of that four lane width is metalled. This road works as spinal cord to this area. Transport Nagar is surrounded by four major roads. Details of these roads are enlisted below.

S. No.	Name of Stretch	Right of way	Metaled portion
1.	Road stretch from Kidwai Nagar to Bara Devi X-ing	150 fts.	5 lanes
2.	Road stretch from Baba Kuti to Juhi Canal X-ing	100 - 150 fts.	2 lanes
3.	Road stretch from Kidwai Nagar to Tat Mill X-ing	200 fts.	4 lanes
4.	Road stretch from Bara Devi to Juhi Canal X-ing	100 fts.	2 - 3 lanes

Main link road in Transport Nagar is having number of different cross link roads placed at right angles. These are having 2 to 3 lanes as metalled portion and 80 ft. to 100 ft. as

TABLE 3.1

ROAD STRETCH INVENTORY IN TRANSPORT NAGAR AREA

S.No.	Name of Stretch	ROAD STRETCH INVENTORY			
		Length in mts.	Right of Way in mts.	Metalled Road in lanes	Road Side Activities
1.	Bara Devi Xing to Site No.1 Xing	600	45	5	- Shopping activities - One side wholesale fruit market and other side truck parking.
2.	Site No. 1 Xing to Kidwai Nagar Xing	800	45	5 – 6	- Semi residential activities
3.	Kidwai Nagar Xing to Transport Nagar Xing	1400	60	4	- Commercial activities - Mainly truck repairs and its accessories
4.	Transport Nagar Xing to Baba Kuti Xing	400	60	2	- Commercial activities
5.	Baba Kuti Xing to Tat Mill Xing	600	40	2 – 4	- commercial activities
6.	Transport Nagar Xing Juhi Canal Xing	1000	60	4	- Both side commercial activities - Truck parking
7.	Baba Kuti Xing to Juhi Canal Xing	(900+450) =1350	30-45	2	- Both side commercial activities - Truck parking
8.	Site No. 1 Xing to Transport Nagar Xing	800	30	2	- Semi commercial activities - Ground floor is used for commercial while first floor is for residential activities
9.	Bara Devi Xing to Juhi Canal Xing (S.H.17)	1300	30	2 – 3	- Semi commercial activities

right of way. A layout of road network of Transport Nagar area has been shown in Fig. 3.1. (KDA, 1992)

3.3. FLOW CHARACTERISTICS OF TRANSPORT NAGAR

To have a feel of the traffic flow conditions on the roads inside and around the Transport Nagar area, the travel time studies were carried out on all these roads during the peak period. This survey was carried out by moving on a four wheeler jeep along the different road stretches between the intersections. The observed travel times are presented in Table 3.2, along with the observed peak hour flows.

Based on these observations the average running speed and the concentration of goods vehicles are also computed and shown in the same table. Analysis shows that the running speed is as low as 15 Km per hour in some of the stretches. The maximum recorded speed was 36 Km. per hour on the road between Transport Nagar intersection to Baba Kuti intersection. The concentration levels as estimated and shown in the table indicates that due to low speeds, the concentration of only the goods vehicle itself is quite high. Stretch between Baba Kuti to Transport Nagar intersection and between Transport Nagar to Juhi Canal intersection shows the maximum concentration as around 21 and 27 vehicles per kilometer and the average speed is about 14 to 15 kilometers per hour respectively, which is as low as the speed of a bicycle. The total concentration level for some of the roads is very close to the situation of almost jamming.

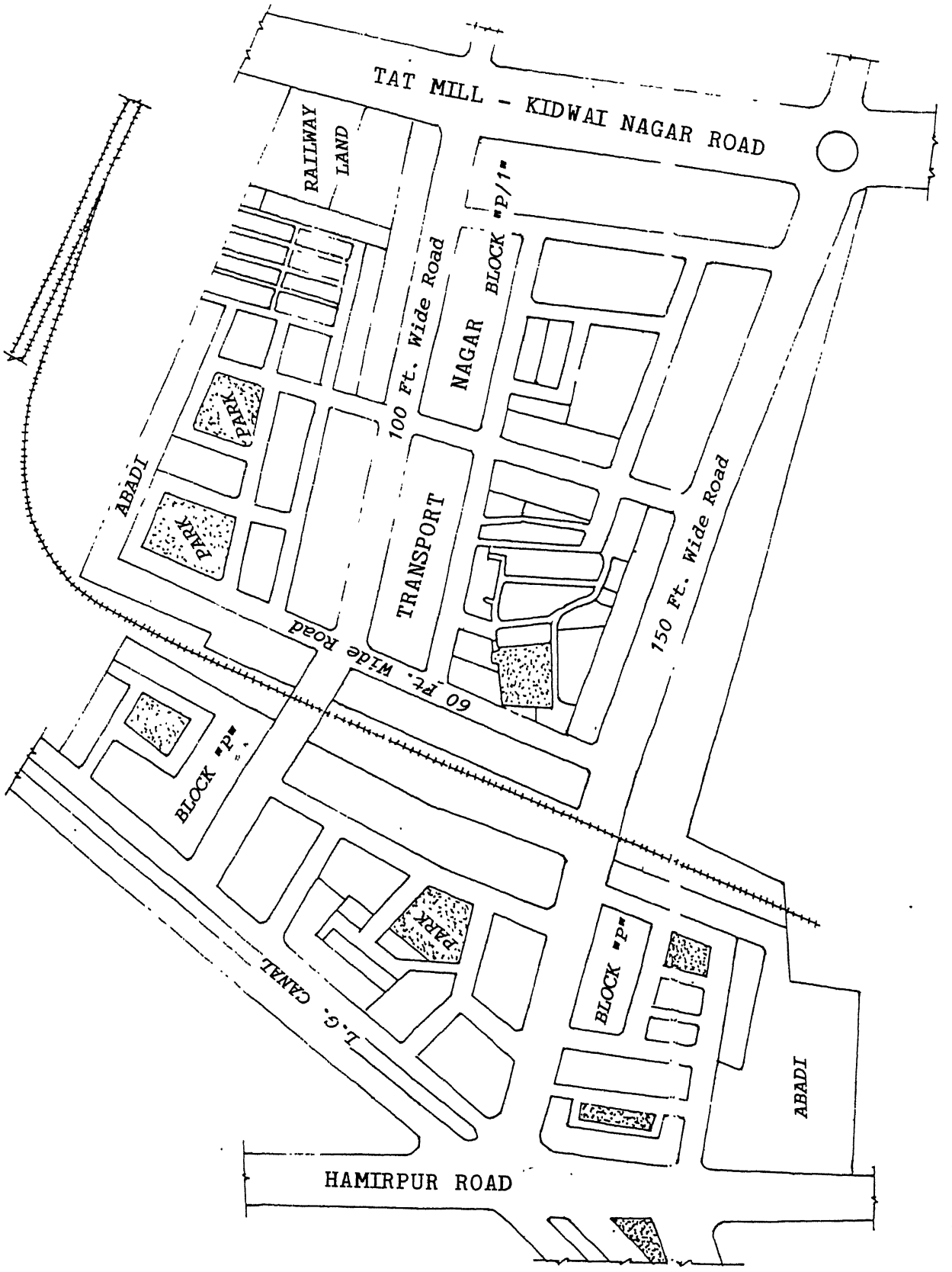


Fig 3.1 LAYOUT PLAN OF TRANSPORT NAGAR AREA

TABLE 3.2

TRAFFIC FLOW CHARACTERISTICS OF TRANSPORT NAGAR AREA

Sl. No.	ROAD STRETCH	LENGTH in mts.	TIME TAKEN in sec.	HOURLY TRUCK VOLUME	AV. SPEED IN KM/HR.	NO. OF LANES	CONCEN-TRATION PER KM.	CONCEN-TRATION NOS./KM /LANE
1.	Bara devi to site no. 1 Xing	600	115	156	18.78	5	8.30 say 8	1.6
2.	Site no. Xing to Kidwai Nagar Xing	800	95	78	30.32	6	2.57 say 3	0.5
3.	Kidwai Nagar Xing to T.P. Nagar Xing	1400	185	206	27.24	4	7.56 say 8	2
4.	T.P. Nagar Xing to Baba Kuti Xing	400	40	271	36.00	2	7.52 say 8	4
5.	Baba Kuti Xing to Tatmill Xing	600	150	304	14.40	2	21.11 say 21	10.56
6.	T.P. Nagar Xing to Juhi canal Xing	1000	240	399	14.99	4	26.62 say 27	6.75
7.	Baba Kuti Xing to Juhi canal Xing	1350	280	176	17.36	2	10.14 say 10	5
8.	Site no. 1 to T.P. Nagar Xing	800	150	79	19.19	2	4.11 say 4	2
9.	Bara devi Xing to Juhi canal Xing	1300	200	188	23.40	2	8.03 say 8	4

Besides the estimated high level of concentration, a number of vehicles are also parked on the roads and loading and unloading operations are carried out. This causes significant reduction in the effective road width for traffic movement. These results indicate that the roads inside the Transport Nagar area are not capable of handling the future traffic demand. Serious attention is to be paid to improve the system.

3.4 GOODS FLOW AROUND TRANSPORT NAGAR

In order to determine the goods flow around Transport Nagar area, a traffic volume survey has been conducted at the following intersections :-

i. Yashoda Nagar intersection

ii. Kidwai Nagar intersection

iii. Naubasta intersection

iv. Bara Devi intersection

v. Tat Mill intersection

Fig. 3.2. shows the average daily truck volume, coming in to the Transport Nagar area. Vehicles coming from different directions pass through the above mentioned intersections for their turnings. Trucks entering Transport Nagar area from south direction of the city are enumerated below :-

(i) From Lucknow and Allahabad side in a bigger proportion and pass through the intersections like Ramadevi, Yashoda Nagar on Kanpur bye pass and Kidwai Nagar.

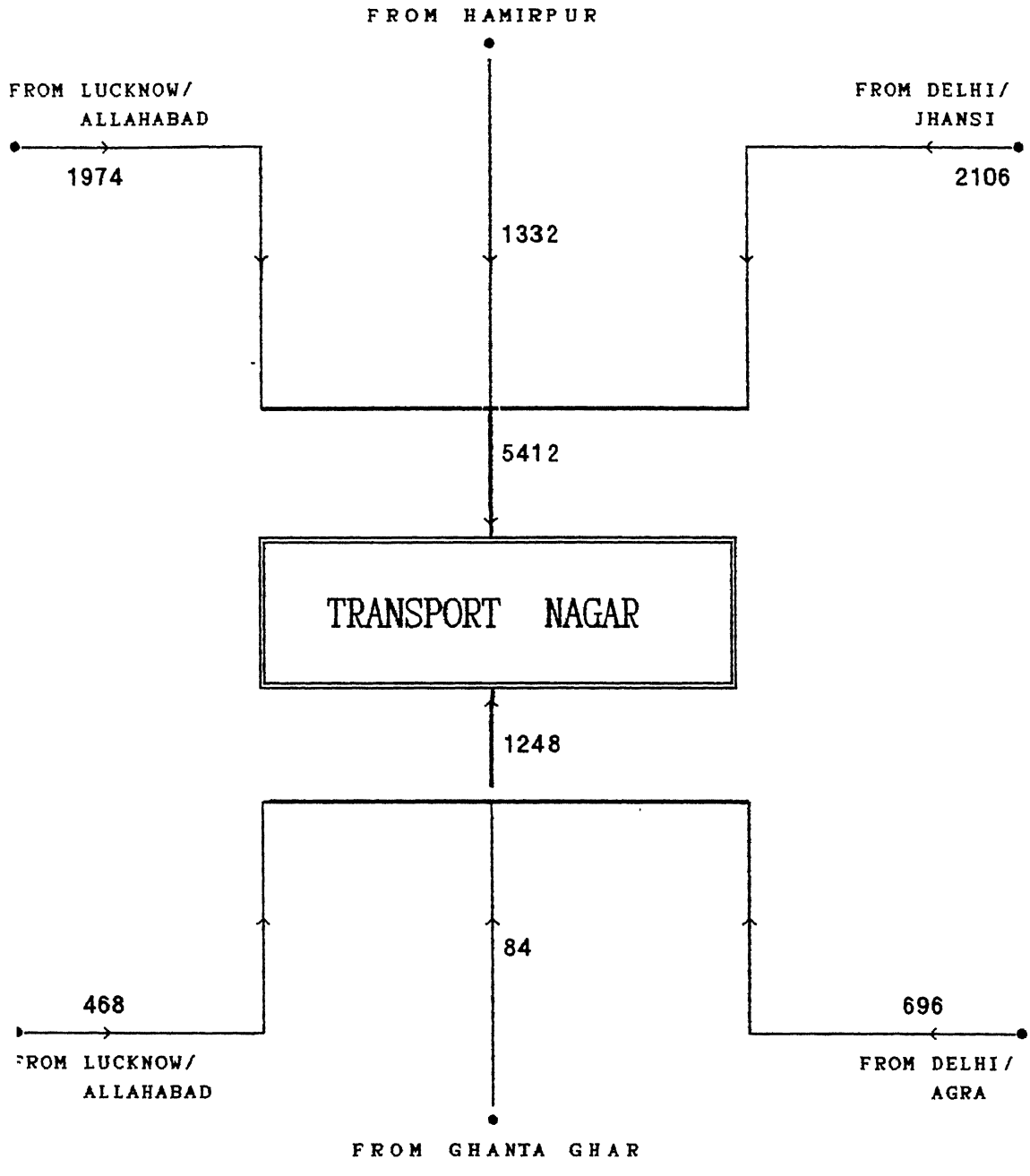


Fig 3.2 AVERAGE DAILY TRUCK VOLUME AT TRANSPORT NAGAR

(ii) From Hamirpur side and come across the intersections like Naubasta and Bara Devi on Hamirpur road.

(iii) From Delhi and Jhansi side and pass through the intersections like Naubasta and Yashoda Nagar on bye pass and Kidwai Nagar.

Similarly trucks entering in Transport Nagar area from north direction are enlisted below :-

i. From Allahabad and Lucknow side in smaller proportion and pass through the intersections like Ramadevi and Tat Mill on G.T. Road.

ii. From Ghantaghar side and come across the Tat Mill intersection.

iii. From Delhi and Farrukhabad side and pass through Kalyanpur, Gurudeo Palace, Rawatpur, Medical College, Coca Cola, Gumti No.5, Jareeb Chauki, Afim Kothi and Tat Mill intersections on G.T. Road.

The above movements of truck traffic reveals the fact that the trucks entering and moving out to their destination from Transport Nagar, face number of intersections and subsequently cause substantial delay and chaos at the intersections coming along.

From the Fig.3.2,it shows that there are more than five thousand four hundred (5412) trucks entering from southern part and around one thousand two hundred (1248) trucks entering from northern part of the Transport Nagar area, which is only 23 percent than that of from southern part. The reason being that

there is a substantial decrease of trucks plying on G.T.Road. It may be because of the fact that the trucks moving on G.T. Road have to face a congested road stretch and so many intersections and railway crossings en-route.

The present location of the Transport Nagar was initially proposed and placed outside the congested and thickly populated area of the city. Due to massive development and heavy commercialization of south Kanpur, Transport Nagar has been surrounded by a densely populated residential colonies and different commercial centers. The change in land use and rapid housing activities created an unpalatable residential atmosphere and at the same time a hazardous and unsafe movement of the goods vehicle. Therefore serious attention is to be paid for the relocation of the Transport Nagar.

3.5 COMPUTER GRAPHICAL REPRESENTATION OF GOODS MOVEMENT

3.5.1 PROBLEM FORMULATION

Display of existing road network and goods traffic movement on various links, is of paramount importance for understanding the goods movement pattern in an area, from management point of view. The goods flow pattern mainly depends upon the condition of links and importance of connecting nodes. For efficient goods movement, a traffic planner has to perform the following tasks :-

(i) To collect the details of existing network ie road width, length and operating speed of various links.

(ii) To asses the existing flow, its modal distribution and variation with time (seasonal, monthly, weakly, daily and hourly variations).

(iii) To draw the road network graphically along with the flows on various links to have a better understandability of the problems.

(iv) To suggest and implement short and long time measures based on (i), (ii), (iii) above and predict the trend of future growth in goods traffic.

3.5.2 PROBLEM LOGIC

To provide a graphic display of existing road network and flow on various links, a computer program is developed. This program displays the width of various links in proportion of flow on it.

The program is inter-active, user friendly and provides the help text from every step of execution of program, by pressing F-1 key. The program is Menu-driven and provides the key board control for backward and forward processing through conditional recursion and the user can go to any step.

The program also provides the facility to know the present sub directory and it's content. The unique feature of program is to save the data supplied by user, in a formatted pattern in a output file, for its reuse in future, if the user desires so.

The axis for the network should be chosen such that the abscissa and ordinate of every node should have a value between 0 to 9,00,000.

3.5.2.1 ALGORITHM

The algorithm for the program is given below.

(i) Read input. The details of various links and flow on them of network can be given either in a input file or can be typed directly in response of the informations asked by the program. The axis for the network should be chosen such that the abscissa and ordinate for every node should lie between 0 to 9 lacs.

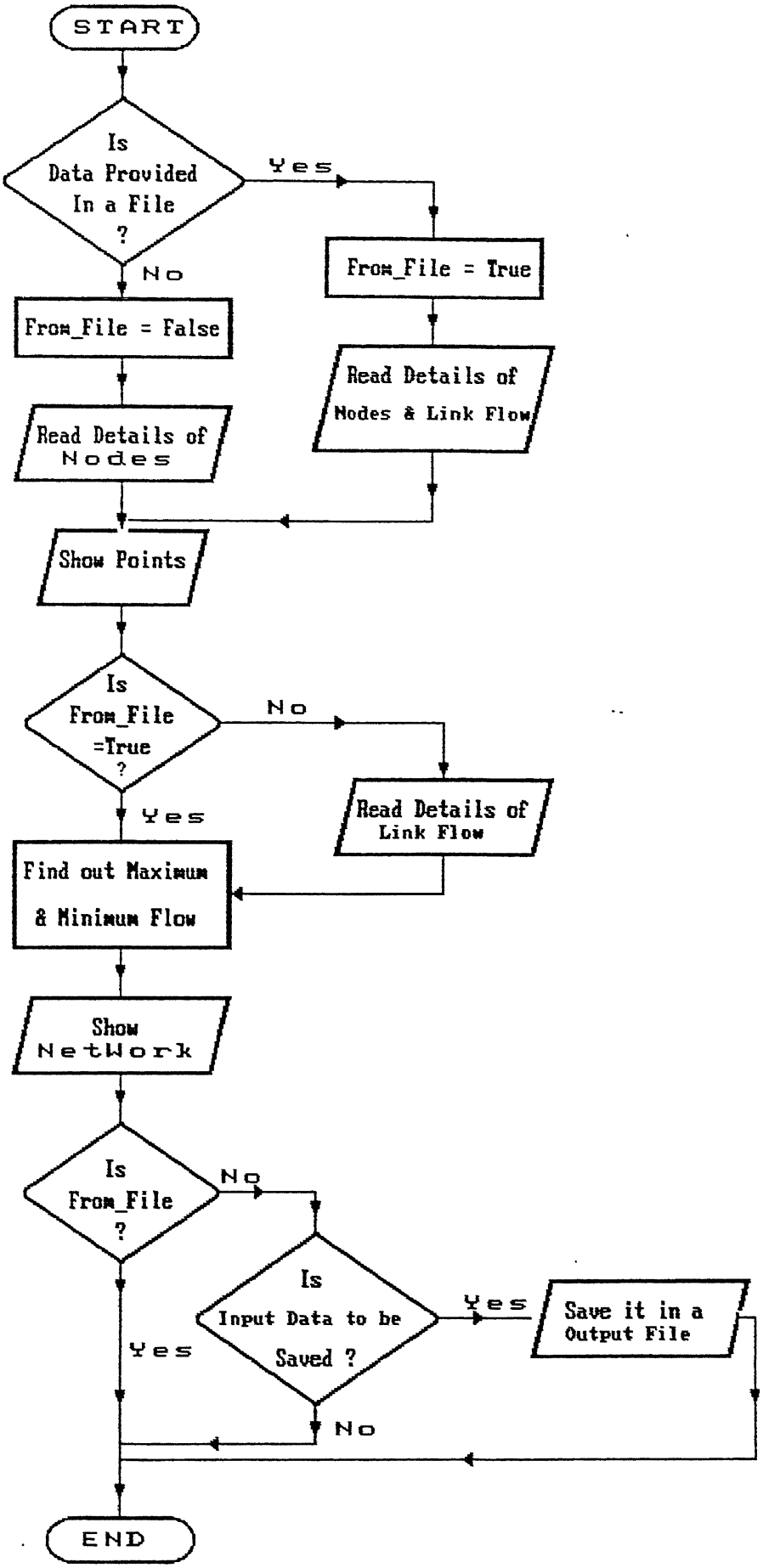
(ii) Display graphically the points. This helps in inclusion of some points, if they were missing.

(iii) Read the details of flow on various links of network if the second option was chosen to provide input (ie not in a file). For non-existing links between two nodes is given with a flow value zero.

(iv) Find maximum values of flow on various links. This provides a logical base to decide the width of links in proportion to flow on them.

(v) Display graphically the network along with flow on various links.

(vi) If the second option was chosen to supply input data, save the data provided, in a formatted pattern in a file for further use , if the user wants to do so.


START
Is Data Provided In a File ?
Yes
No
From_File = True
From_File = False
Read Details of Nodes & Link Flow
Read Details of Nodes
Show Points
Is From_File =True ?
No
Yes
Read Details of Link Flow
Find out Maximum & Minimum Flow
Show NetWork
Is From_File ?
No
Yes
Is Input Data to be Saved ?
Yes
No
Save it in a Output File
END

3.5.2.2 FLOW CHART

The flow chart for the above program developed, is given in Figure 3.3.

3.5.2.3 PROGRAM DEVELOPMENT

The above program " Network.Pas " is written in Turbo Pascal Version 5.0. For compilation, it requires the Turbo Pascal Compiler and standard units namely Crt, Dos, and Graph.

The execution of program requires either Herculis Mono Adopter (for Black and White Graphic Display) or Color Graphic Adopter / Enhanced Graphic Adopter (for Color Graphic Display), the executable file " Network.Exe " in DOS environment. It also requires drivers (.BGI) and fonts file (.CHR) for graphic display, in the same directory.

This Program is used for sixteen identified intersections (Nodes) and flow between the nodes. Fig 3.4 shows the different nodes of the network and Fig 3.5 shows the width of various links in proportion to flow on them.

3.6 CONCLUSION

The above findings reveals the fact that there has been a complete defiance of provisions of the Master Plan in terms of land use and road side activities. The administrative apathy for the traffic management and taking of such politico - administrative decisions that are in conducive to a healthy and safe transport environment, have caused irregular and

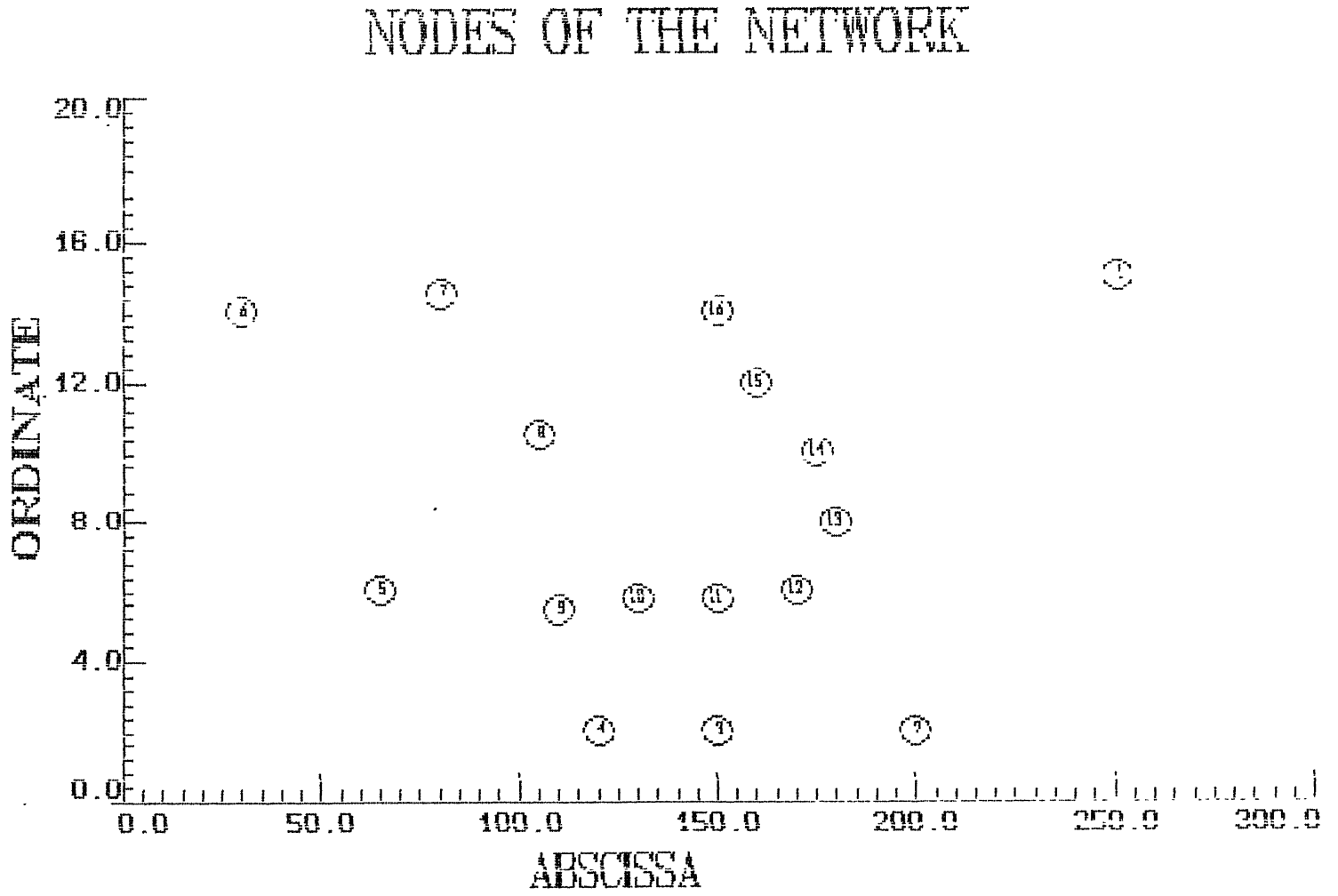


Fig 3.4 LOCATIONS OF SIXTEEN IDENTIFIED AND SURVEYED NODES

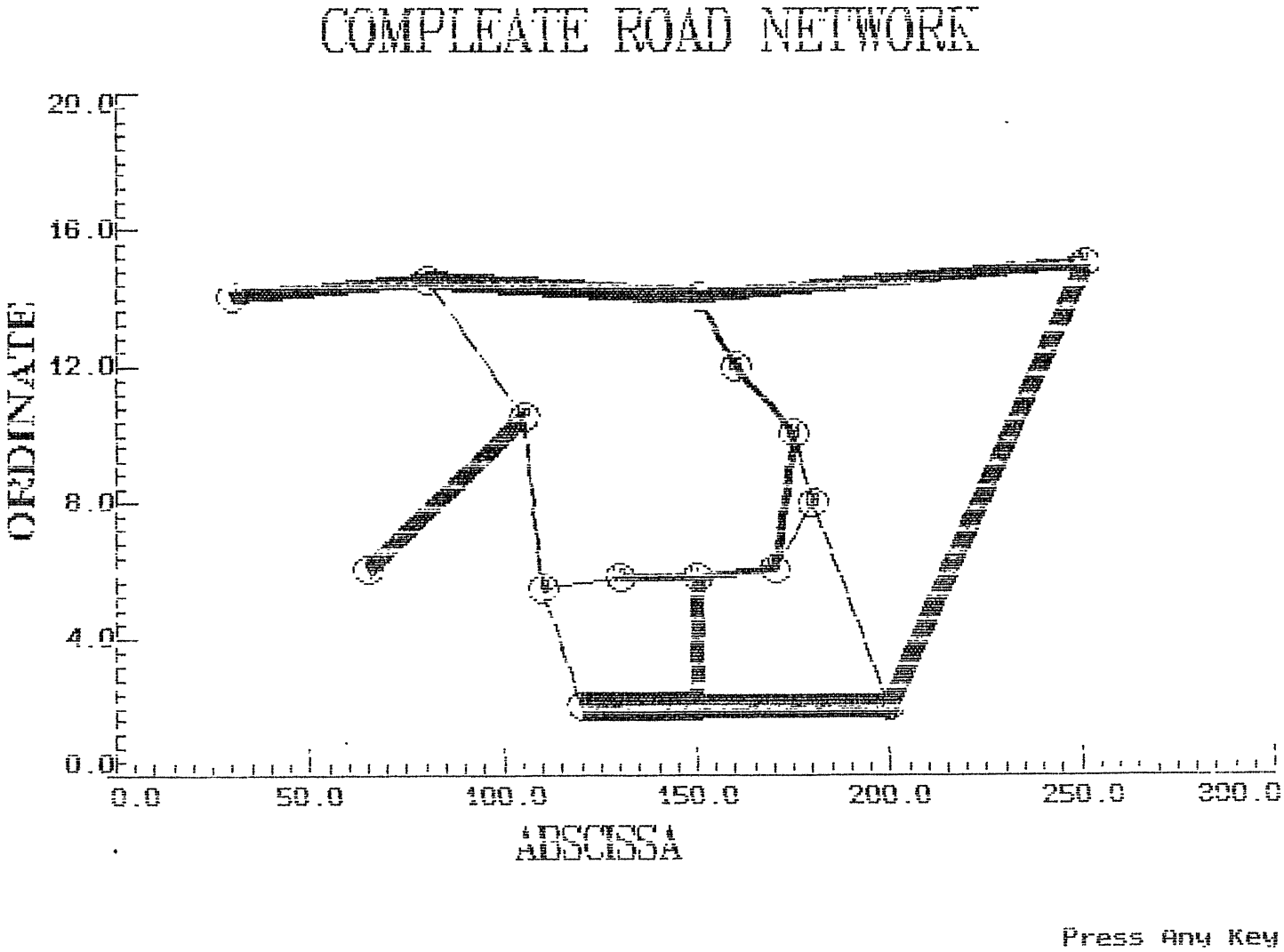


Fig 3.5 FLOW AMONG THE SIXTEEN IDENTIFIED AND SURVEYED NODES

inappropriate uses of the road side around and inside Transport Nagar area. The traffic pattern from the different directions to the Transport Nagar indicates that there is a tremendous commercial pressure and goods vehicular flow on the southern part of the city between Kanpur bye pass and Transport Nagar. The above conditions and cluster of commercial vehicles forces the unsafe living conditions of the resident of this area, which will further aggravate in near future. Therefore proper concern is needed and a serious thought is to be given for the relocation of the Transport Nagar.

4. STUDY OF INTER-CITY GOODS MOVEMENT

4.1. INTRODUCTION

Kanpur is the biggest industrial and populated city in U.P. Initially at the beginning of the century, the population of Kanpur was about 2 lacs, which remained almost static up to 1931 due to minimum industrial influence. Because of number of cotton and woolen mills and ordinance factories started between 1931 to 1941, the population of the city has doubled and thereafter it shows almost steady growth. This total variation in population in different decades can be viewed from Table 4.1 and Figure 4.1 (Census 1991).

Population of different KAVAL (major) cities has also grown up but the growth rate was lesser than that of Kanpur city. Industrial growth and other commercial activities are also less in comparison with Kanpur. Comparison of population growth for KAVAL cities of U.P. is shown in Table 4.2 and Figure 4.2 (Census 1991) . Due to growth in population and industrial/commercial activities, the inter-city goods movement between Kanpur to Agra, Lucknow and Allahabad has raised up substantially. These cities are involved either for direct trade affairs or are used as halting stations en-route.The knowledge of inter-city goods movement pattern between Kanpur to Agra, Lucknow and Allahabad has its importance and utility for the analysis and characteristics of inter-city truck movement passing through the city.

TABLE 4.1

POPULATION OF KANPUR CITY

YEAR	POPULATION	DECADAL VARIATION (in Percent)
1901	2,02,797	0.0
1911	1,78,557	11.9
1921	2,16,436	21.2
1931	2,43,755	12.6
1941	4,87,324	99.9
1951	7,05,333	44.7
1961	9,71,062	37.6
1971	12,75,242	31.3
1981	16,39,064	28.5
1991	21,94,278	33.87

Source : Census of India, 1991.

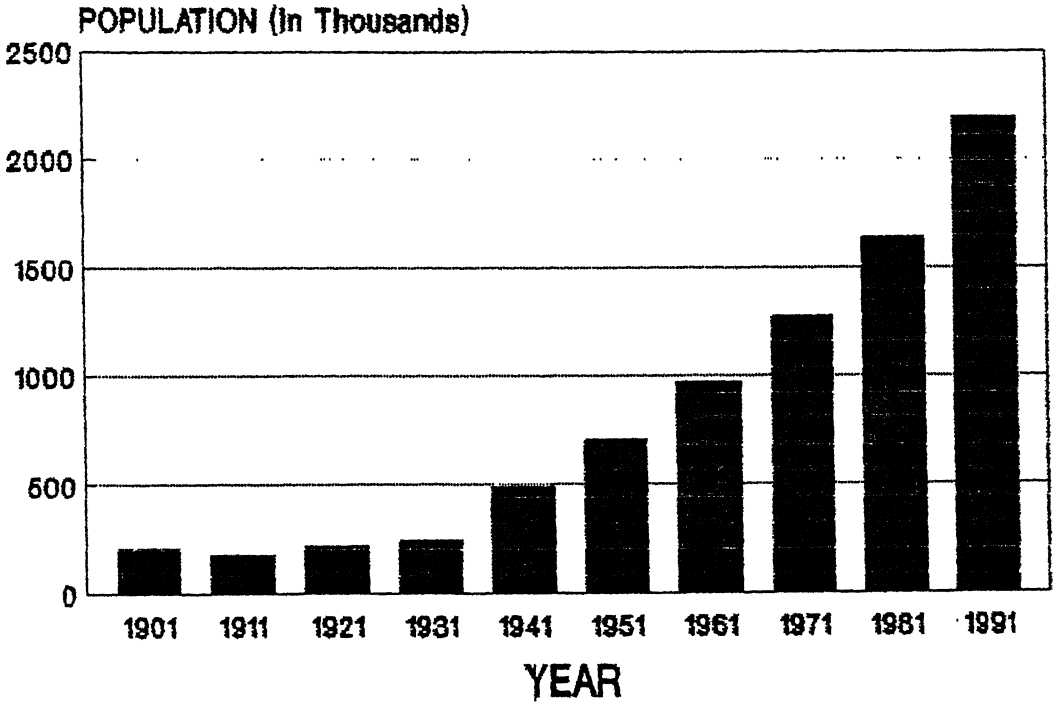


FIG. 4.1 DECADAL REPRESENTATION OF POPULATION FOR KANPUR CITY

TABLE 4.2

POPULATION OF KAVAL CITIES

CITY	POPULATION (In Lacs)		GROWTH RATE (In Percent)		
	1981	1991	1961-71	1971-81	1981-91
KANPUR	16.39	21.94	31.32	32.39	33.86
AGRA	7.70	9.03	24.75	21.39	17.27
VARANASI	7.94	10.18	23.85	30.79	28.37
ALLAHABAD	6.42	8.42	19.11	25.22	31.15
LUCKNOW	10.07	16.69	24.14	23.68	65.90

Source : Census of India, 1991

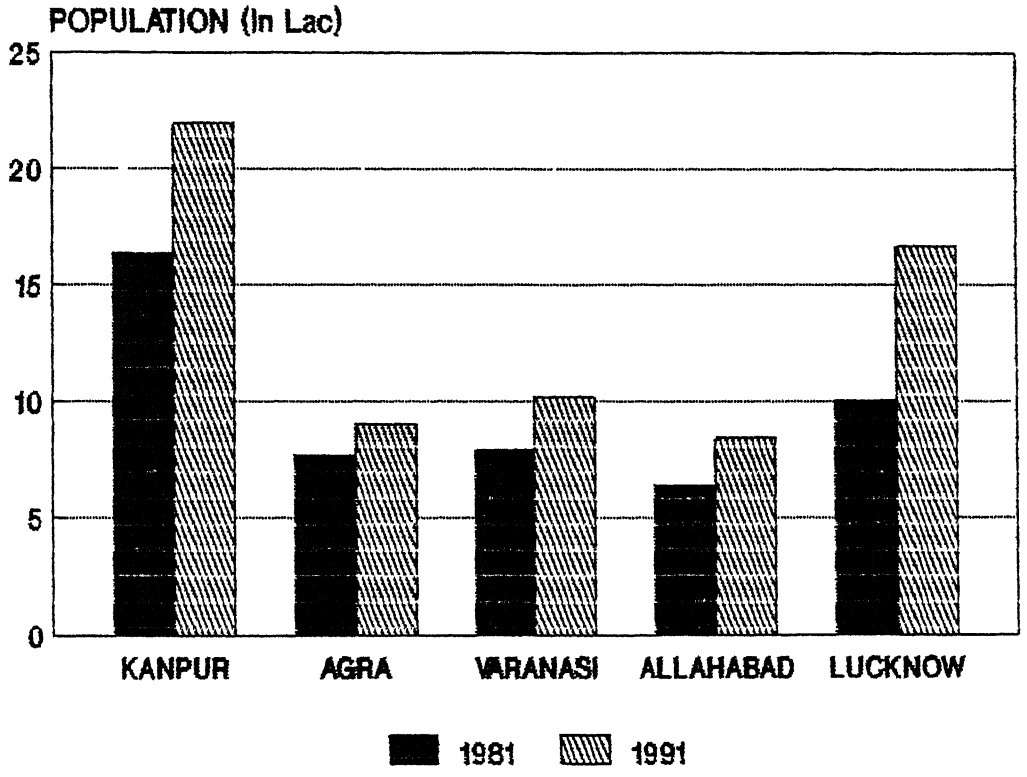


FIG. 4.2 POPULATION OF 'K A V A L' CITIES

4.2. EARLIER STUDIES FOR INTER-CITY GOODS MOVEMENT

The inter-city goods movement to/from Kanpur, approaches through the following six roads.

(i) New Lucknow Road (N.H.25).

(ii) Kalpi Road (N.H.2/N.H.25).

(iii) G.T. Road towards Delhi (S.H.22).

(iv) G.T. Road towards Allahabad (N.H.2).

(v) Old Lucknow Road.

(vi) Hamirpur Road (S.H.17).

Observations have been made in the past decade to determine the inter-city goods movement. Data was collected in these studies, at the following six locations, on the outer cordon of the city.

(i) Jajmau on New Lucknow Road.

(ii) Bhauti on Kalpi Road.

(iii) Kalyanpur on G.T. Road (towards Delhi).

(iv) Ahirwan on G.T. Road (towards Allahabad).

(v) Ganga Ghat on Old Lucknow Road.

(vi) Bingawan on Hamirpur Road.

Data for the inter-city goods movement conducted in 1982-83 by Kanpur Municipal Corporation (Table 4.3) shows that a total of 6409 vehicles per day enter and leave the city limits. Out of these, 3106 vehicles (48.48 percent) enter the city, while 3303 vehicles (51.52 percent) leave out of the same. The highest volume is observed on the two stretches of National Highway 25,i.e. towards Jhansi 28.17 percent and towards Lucknow 24.84 percent. An earlier study has indicated that in 1966 the daily

TABLE 4.3

AVERAGE DAILY TRUCK VOLUME AT DIFFERENT OCTROI STATIONS
BY
KANPUR MUNICIPAL CORPORATION

Octroi Stations	Year 1982 - 83			Percent
	IN	OUT	TOTAL	
KALYANPUR	580	613	1198	18.68
BHAUTI	875	931	1806	28.17
BINGAWAN	305	478	783	12.20
AHIRWAN	518	484	1002	15.62
JAJMAU (New Ganga Bridge)	810	783	1593	24.84
GANGAGHAT (Old Ganga Bridge)	18	14	32	0.49
TOTAL (PERCENT)	3106 (48.48%)	3303 (51.52%)	6409 (100%)	100.00

truck volume entering the city limits was only 557 (Dr Marwah B.R. 1977). This means that in a time span of sixteen years (1966 - 1982), the incoming truck volume has increased to almost six times.

The results of the goods traffic volumetric study conducted in 1987-88 by Consulting Engineering Services (CES 1987) and in 1990-91 by National Transportation Planning and Research Center (NATPAC 1991) are also presented in Table 4.4 and Table 4.5 respectively. This shows that nearly 83,470 vehicles enter and exit from all the main arterials/National/State highways from/to the city on a normal working day. It is also observed that around 47 percent,(in total) on average, fast moving vehicles and around 53 percent,(in total) on average, slow moving vehicles enter and exit from the city.

The Origin-Destination study conducted by the NATPAC also includes the mode wise composition of traffic at outer cordon locations for fast vehicles (Trucks/Non Trucks) and slow vehicles (Cycles/Non Cycles). This has been shown in Table 4.6. It reveals that on an average daily traffic, truck traffic shows a highest percentage in volume among all other fast moving vehicles. On an average, fast moving vehicles constitutes 50 to 66.67 percent, out of that only trucks constitute half of the total fast vehicles.

The above observations reveals the fact that trucks in Kanpur possess an important and major share among all other traffic and any change in planning and policy in truck movement may change the transport scenario of the city.

TABLE 4.4

AVERAGE DAILY TRUCK VOLUME AT DIFFERENT OCTROI STATIONS
BY
CONSULTING ENGG. SERVICES [C.E.S.]

Octroi Stations	Year 1987 - 88			Percent
	IN	OUT	TOTAL	
KALYANPUR	855	791	1646	17.33
BHAUTI	1293	1184	2477	26.08
BINGAWAN	690	528	1218	12.83
AHIRWAN	823	753	1576	16.50
JAJMAU (New Ganga Bridge)	1191	1342	2533	26.67
GANGAGHAT (Old Ganga Bridge)	22	23	45	0.48
TOTAL (PERCENT)	4874 (51.13%)	4621 (48.87%)	9495 (100%)	100.00

TABLE 4.5

AVERAGE DAILY TRUCK VOLUME AT DIFFERENT OCTROI STATIONS
BY
NATIONAL TRANSPORTATION PLANNING AND RESEARCH CENTRE (NATPAC)
(FOR THE YEAR 1990-91)

Sl. No.	Octroi Station	Type	Fast Vehicle	Slow Vehicle	Total Traffic
1	Kalyanpur	Inbound	3928	1640	5568
		Outbound	2950	1320	4270
		Total	6878(70)	2960(30)	9838
2	Bhauti	Inbound	2969	2028	4997
		Outbound	3702	1306	5008
		Total	6671(67)	3334(33)	10005
3	Bingawan	Inbound	1937	2337	4274
		Outbound	1925	2569	4494
		Total	3862(44)	4906(56)	8768
4	Ahirwan	Inbound	3746	2858	6604
		Outbound	2167	1265	3432
		Total	5913(59)	4123(41)	10036
5	Jajmau	Inbound	3154	1758	4912
		Outbound	3177	2545	5722
		Total	6331(59)	4303(41)	10634
6	Gangaghat	Inbound	3619	14961	18580
		Outbound	5706	9903	15609
		Total	9325(27)	24864(73)	34189
GRAND TOTAL			38980(47)	44490(53)	83470

Note : Figure in brackets indicate percentage of total traffic.

TABLE 4.6

MODEWISE COMPOSITION (IN PERCENTAGE) OF TRAFFIC
AT
OUTER CORDON LOCATIONS

Sl. No.	Octroi Stations	Fast Vehicles			Slow Vehicles			TOTAL
		TRUCK	OTHERS	TOTAL	CYCLE	OTHERS	TOTAL	
1	Kalyanpur	31	39	70	29	1	30	100
2	Bhauti	35	32	67	29	4	33	100
3	Bingwan	19	25	44	52	4	56	100
4	Ahirwan	25	34	59	39	2	41	100
5	Jajmau	30	30	60	37	3	40	100
6	Gangaghat	-	23	23	60	17	77	100

Source : O.D. Survey by NATPAC (July 1991)

4.3. GOODS TRAFFIC SURVEY

To have a realistic estimate of the present day goods movement, the traffic volume surveys were also conducted in this study at the six octroi stations, during May 1992. Summery of the daily goods traffic volume as recorded are presented in Table 4.7. A Total of 15,774 goods vehicles per day were recorded compared to only 6409 goods vehicles in 1982 and 9495 in 1987. This survey shows that the volumes are again the highest on the Kalpi and Lucknow Roads.

4.4. TREND IN GROWTH OF TRUCK TRAFFIC

4.4.1. GROWTH OF TRUCK TRAFFIC WITH TIME

To analyse the truck traffic, it is essential to know the trend of growth of trucks in the past. Table 4.8 presents the truck volume in the year 1982-83 and in 1992-93 and its compound growth rate for incoming/outgoing and total truck volume at different outer cordon locations. The table also shows that there is an increasing trend in growth at every outer cordon/octroi stations except at Ganga Ghat, where there is a restriction for heavy vehicles. This also shows that the highest annual growth rate (compound) for incoming truck traffic is at Ahirwan octroi station (12.97 percent) while for outgoing truck traffic, it is at Bhauti (10 percent). The highest annual total growth rate is found to be at Ahirwan octroi station (11.38 percent), while the minimum annual total growth rate is at Jajmau octroi station (7.98 percent) except Ganga Ghat. Table 4.8 also reveals this fact that in Kanpur, annual growth rate for total truck traffic

TABLE 4.7

DAILY TRUCK VOLUME AT DIFFERENT OCTROI STATIONS

Octroi Stations	Years 1992 - 93			Percent
	IN	OUT	TOTAL	
KALYANPUR	1890	1375	3265	20.70
BHAUNTI	1478	2415	3893	24.68
BINGAWAN	960	1002	1962	12.44
AHIRWAN	1754	1192	2946	18.68
JAJMAU (New Ganga Bridge)	1962	1708	3670	23.26
GANGAGHAT (Old Ganga Bridge)	2	6	8	0.05
TOTAL (PERCENT)	8046 (51%)	7698 (49%)	15774 (100%)	100.00

TABLE 4.8

GROWTH OF TRUCKS AT OUTER CORDON STATIONS DURING THE PERIOD

FROM 1982-83 TO 1992-93

ıter ›rdon :ations	Years 1982-83 IN	OUT	TOTAL	Years 1992-93 IN	OUT	TOTAL	Average Annual Growth Rate (Compound) (in percentage) IN 1982-92	OUT 1982-92	TOTAL from 1982-92
ıLYANPUR	580	613	1198	1890	1375	3265	12.53	8.41	10.54
IAUNTI	875	931	1806	1478	2415	3893	5.38	10.00	7.98
NGAWAN	305	478	783	960	1002	1962	12.15	7.68	9.62
:IRWAN	518	484	1002	1754	1192	2946	12.97	9.43	11.38
JMAU ew Ganga ridge)	810	783	1593	1962	1708	3670	9.24	8.11	8.70
NGAGHAT ld Ganga ridge)	18	14	32	2	6	8	-19.72	-8.12	-12.94
	3106	3303	6409	8046	7698	15744	9.98	8.82	9.40

between 1982-83 to 1992-93 is 9.40 percent per year for all the entry/exit points.

A graph has been plotted between total number of incoming / outgoing truck volume with year separately (Fig 4.3). We find a curve which shows exponential nature. Assuming the same trend of the curve for the year 2001, best fit equations have been determined. These equations are as follows :-

$$T = \exp(0.103877\ Y) * 1.13115\ E - 86 \quad \text{------}(i)$$

For incoming trucks

$$T = \exp(0.085493\ Y) * 8.26660\ E - 71 \quad \text{------}(ii$$

For outgoing trucks

Where

T = Total number of trcuks.

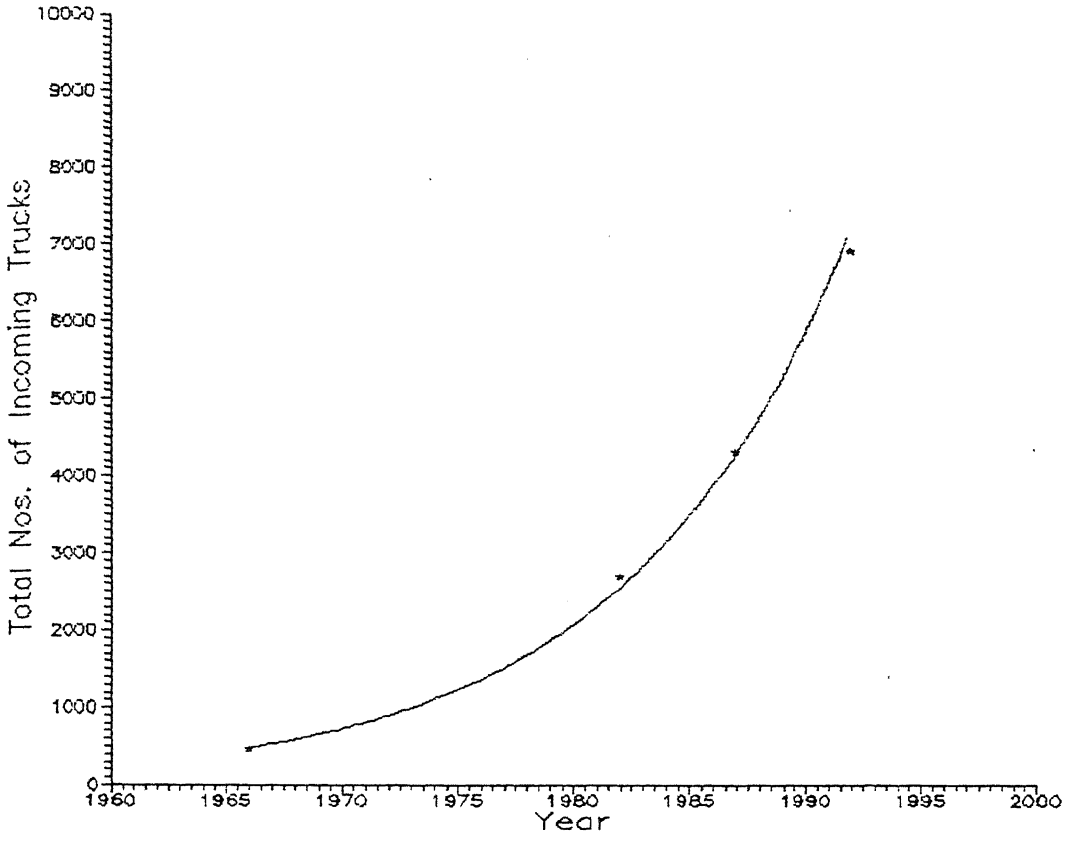
Y = Year

Using above equations the total number of incoming and outgoing trucks for the year 2001 are found to be 21137 and 16324 respectively.

Similarly a graph has been plotted separately between total number of trucks with year (Figure 4.4). This curve also shows an exponential nature and the best fit equation for this curve has been determined and given below :-

$$T = \exp(0.089829\ Y) * 3.0134\ E - 74 \quad \text{------}(iii)$$

Using above equation no. *(iii)* the total truck volume (Incoming + Outgoing) for the year 2001 has been calculated and is found to be 34870.



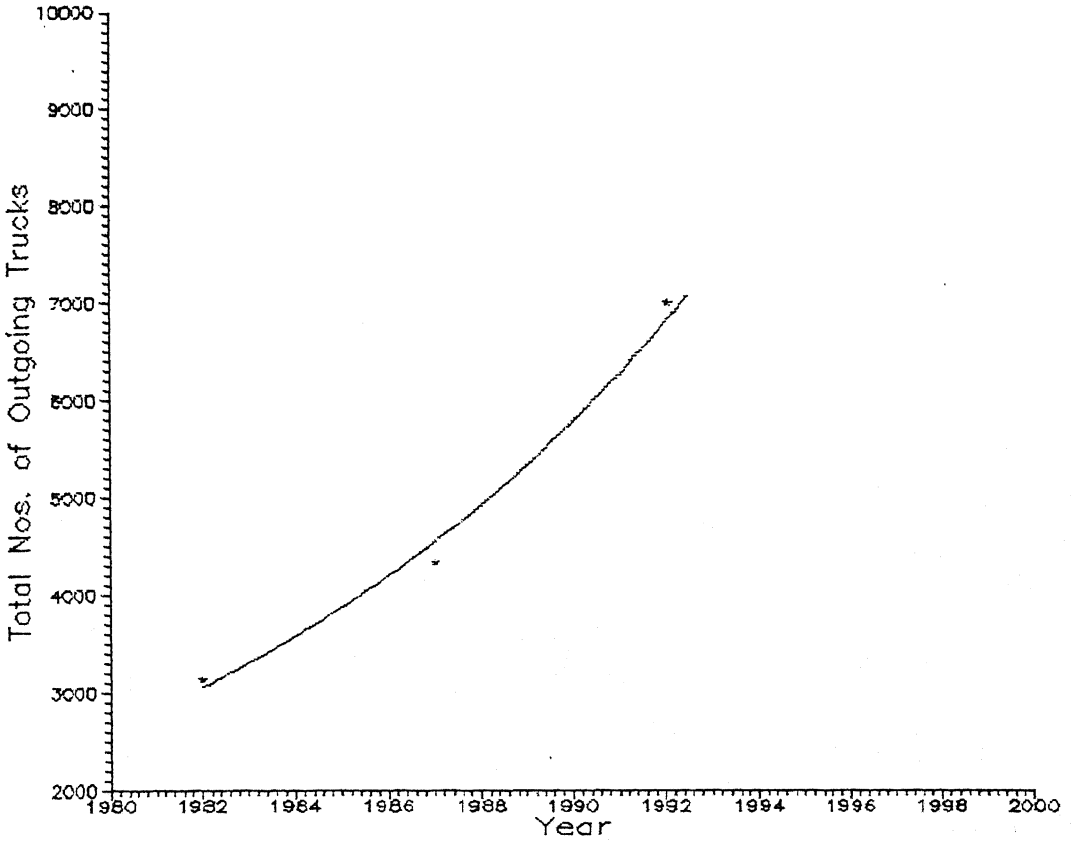
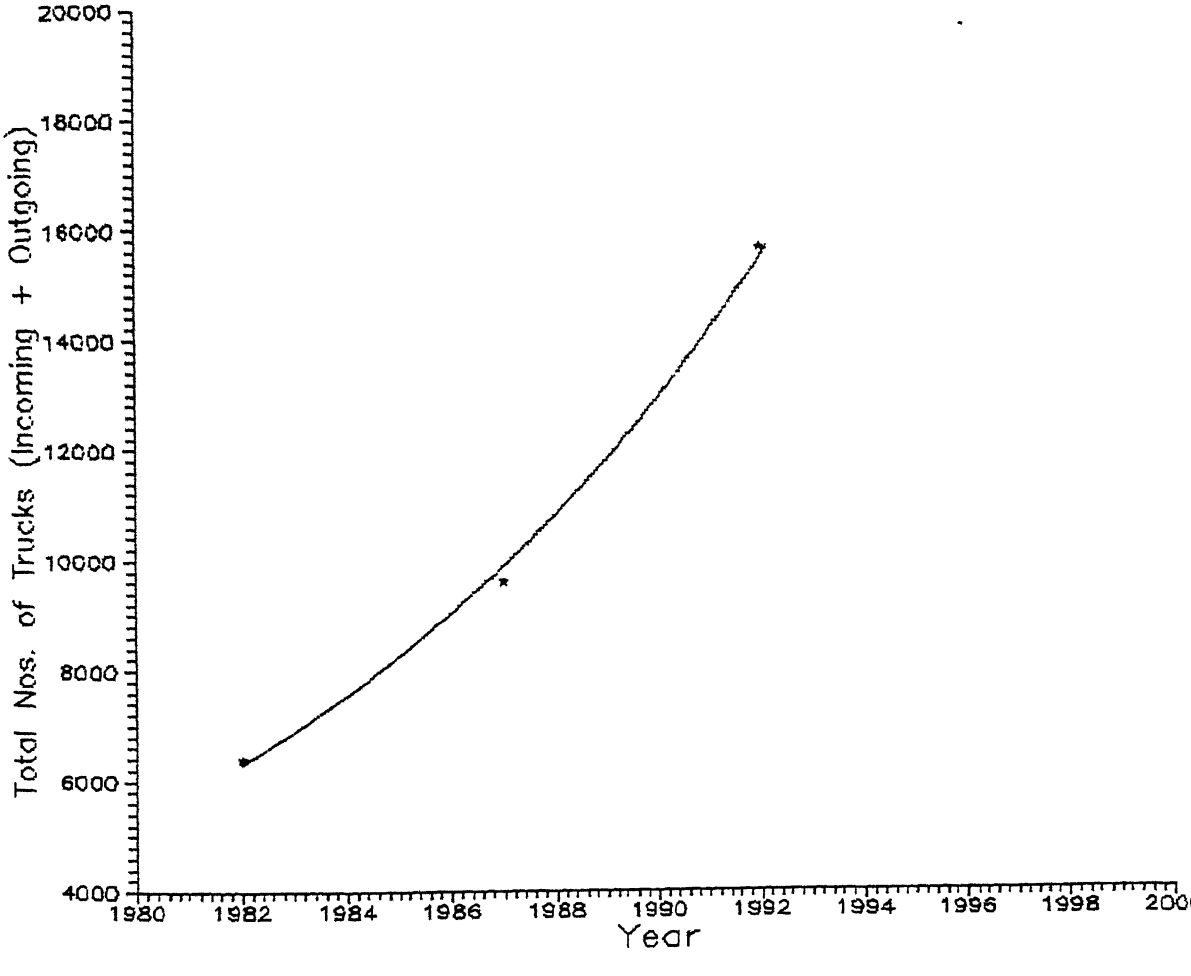


Fig. 4.3 RELATIONSHIP BETWEEN INCOMING AND OUTGOING TRUCK VOLUME WITH TIME


20000
18000
16000
14000
12000
10000
8000
6000
4000
Total Nos. of Trucks (Incoming + Outgoing)
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
Year

4.4.2. GROWTH IN GOODS TRAFFIC WITH POPULATION

Trend in growth of goods traffic can also be co-related with growth in population. Table 4.1 shows that the yearly compound growth rate of population is 2.95 percent per year. Assuming the same growth rate, population for the year 1982 and 1992 has been calculated. The truck volume and population for the years 1982, 1987, 1991 and 1992 is mentioned below :-

Year	Population (in Lacs)	Total No. of Trucks (Incoming+Outgoing)
1982	16.87	6409
1987	19.51	9495
1991	21.94	13952
1992	22.56	15744

(Decadal variation of growth = 2.95 percent per year)

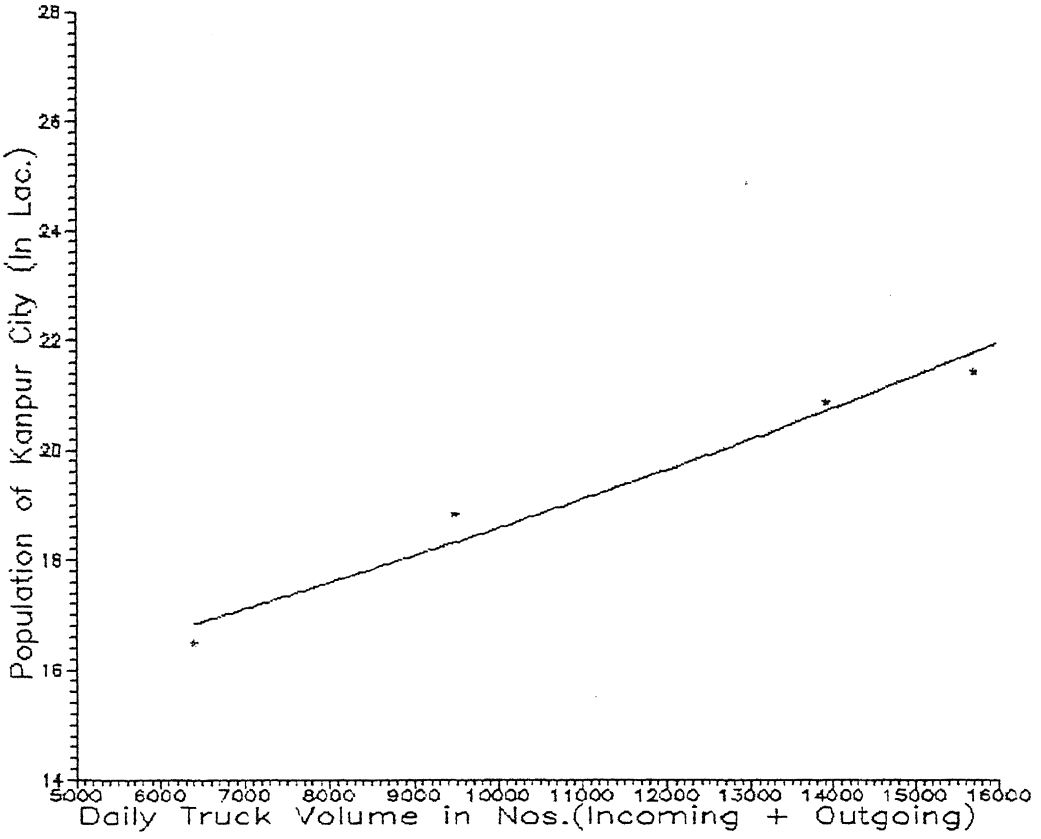
The above values are plotted and two best fit equations are determined (Fig 4.5). When the best fit is done for the linear pattern then the equation is

$$T = 0.000602953\ P + 13.3616 \quad \text{------}(iv)$$

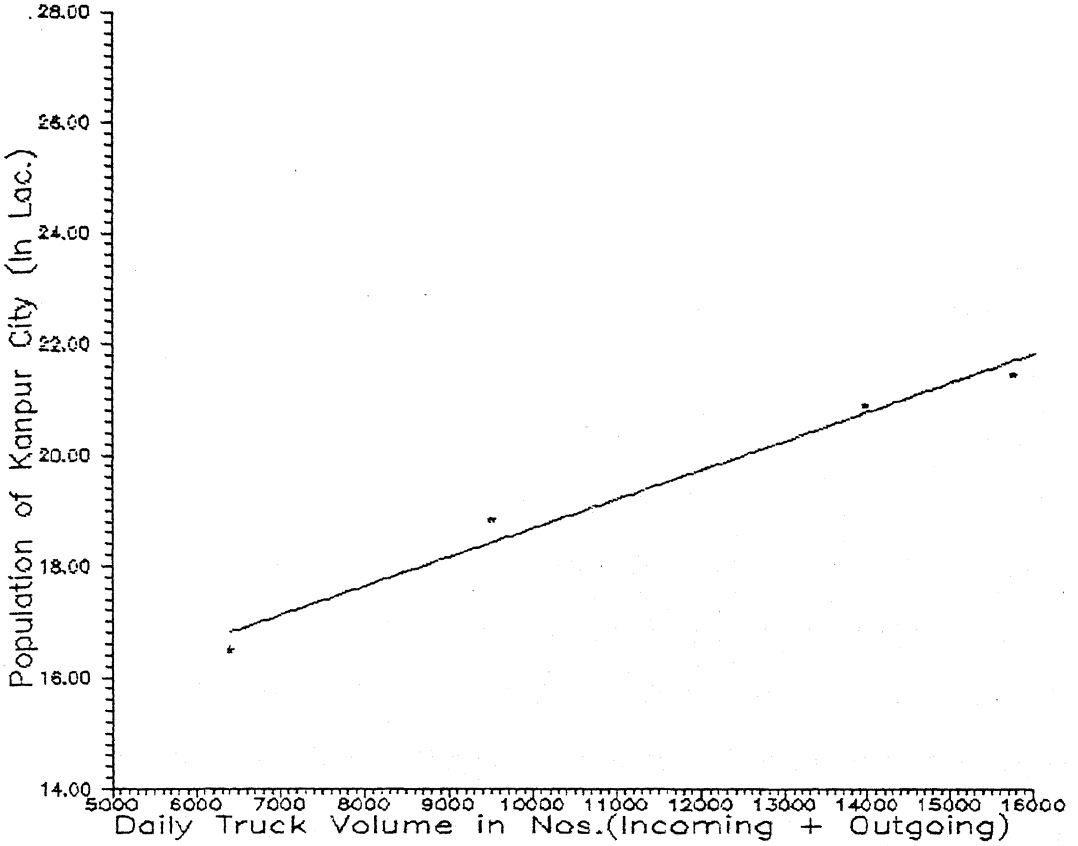
and when it is tried for exponential pattern then the best fit equation is

$$T = \exp(\ 3.06058\ E\ -5\ P\ )\ *\ 14.1838 \quad \text{------}(v)$$

Where 'T' is the number of trucks and 'P' denotes the population.



Exponential pattern



Linear pattern

Fig. 4.5 RELATIONSHIP BETWEEN TOTAL TRUCK VOLUME WITH POPULATION OF KANPUR

Using above equations (*iv*) and (*v*), the total number of trucks (Incoming + Outgoing) in the city are calculated for the year 2001. The values are found to be 23715 and 26453 respectively. If we compare these values with the values found in Para 4.4.1, we find that values found in best fit exponential equation is more nearer to the previous values than linear one.

4.5. COMPUTER GRAPHICAL REPRESENTATION OF INTER - CITY GOODS MOVEMENT

The computer program developed and described in Article (3.5),for graphically representing the intra-city goods movement, can also be effectively used for computer graphical representation of inter-city goods movement, by treating cities as nodes in the program.

4.6. ANALYSIS OF TRUCK LOAD

4.6.1. EFFECT OF HEAVILY LOADED TRUCKS ON ROAD SURFACE

Roads which carrying majority of the heavy commercial vehicles are :-

- G.T.Road,
- Kalpi Road and
- Kanpur Bye pass.

These roads are the main arterials of the city but are providing a poor level of service to the vehicles. These roads have widths of varying two to four lanes and paved shoulders are also provided on some of the stretches. A detailed examination of these roads was carried out and it is observed that road

condition, in general, are not up to the desired levels. The road deterioration in the form of crest failure provides a very uneven surface, causing excessive damage to the vehicles and increase consumption of oils and fuels.

These roads designed as per the Class-A Loading of the IRC, having resurfaced number of times over the last fifteen to twenty years. Though the pavement thickness is adequate and sub grade also has been compacted over time, still failure on the surface are quite prominent. It has been observed through experimental data conducted by the Ministry of Transport that the commercial vehicles are generally overloaded causing more deterioration to the pavement structure. For a proper design of the pavement, it is required that the distribution of the axle loads be also estimated along with the volume of vehicles. This strategy also aimed at knowing the distribution of vehicle loads on different roads and to study their characteristics. Due to non-availability of the equipments for recording the axle loads of different vehicles, it was planned to record the loads for the vehicles, as recorded for various Government Approved Weighing Stations (GAWS). After getting the information of the different weighing stations and their locations, the following three GAWS were identified for data collection. These three weighing stations are :-

-G A W S - 1 (Jagdish Dharm Kanta) :- It is situated between inner and intermediate cordon, near Fazal Ganj intersection, deals mainly light commercial vehicles.

-G A W S - 2 (Avery Dharm Kanta) :- It is situated between intermediate and outer cordon, near Jhakharkati Over Bridge, deals with light and heavy commercial vehicles.

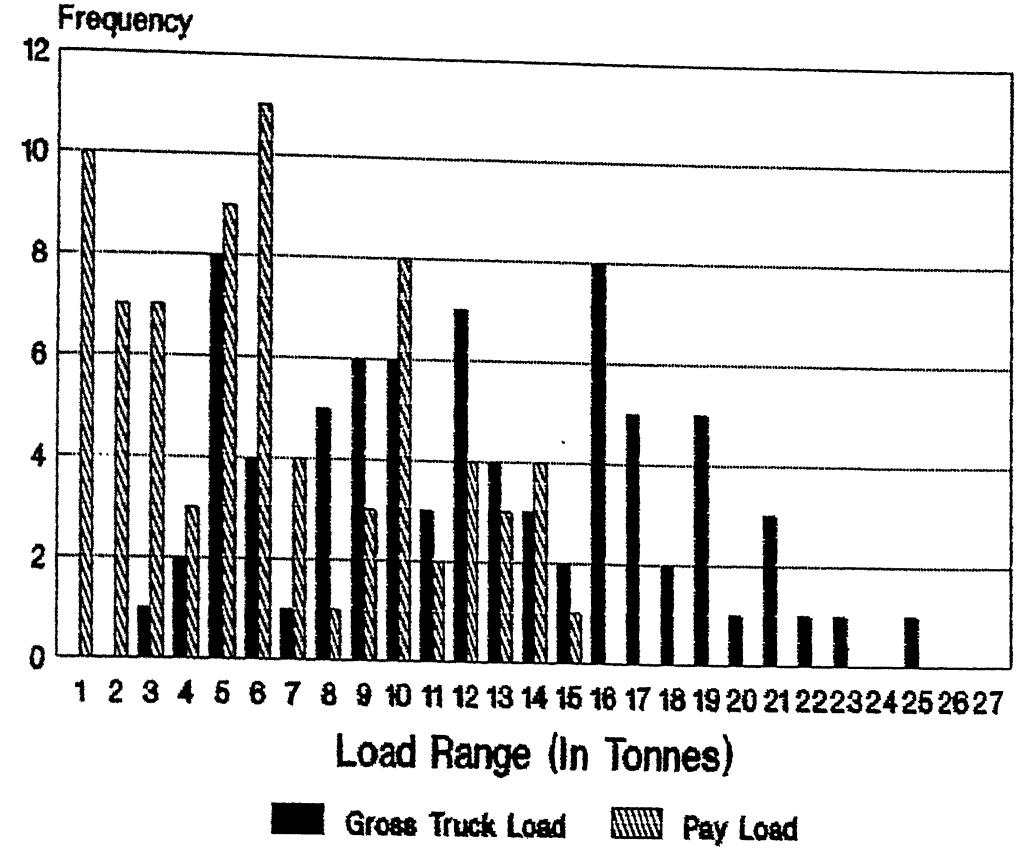
-G A W S - 3 (Accurate Dharm Kanta) :- It is situated beyond the outer cordon ie beyond Bye pass. It deals with mainly heavy commercial vehicles.

The data as the above, three weighing stations have different characteristics, the recording of data on these will show the varying patterns of truck loads on different roads.

The truck load data was obtained for a period of 24 hours on all these weighing stations. In all, the load data for 316 vehicles was recorded. The smallest sample size on these weighing stations was 75 and the highest was 164. The analysis of the vehicle data was done separately for each station and also combined for all the stations. Knowing the total gross truck load and the vehicle load, the pay load was also determined. The histograms for the Gross truck loads and the Pay loads for all these three weighing stations is shown in Figure 4.6, 4.7 and 4.8. The cumulative frequency distribution are also shown along with the above figures.

4.6.2. ESTIMATION OF LOADING PATTERN

Based on above figures 4.6, 4.7 and 4.8, Figure 4.6 shows that for GAWS-1, which is totally within the city, trucks of the gross load range of 15 to 16 tones and pay load range of 5 to 6 tones have their business in this part of the city. Calculation for the means ($\overline{x}$) and standard deviations (σ) of gross loads and pay loads have been done and presented here.



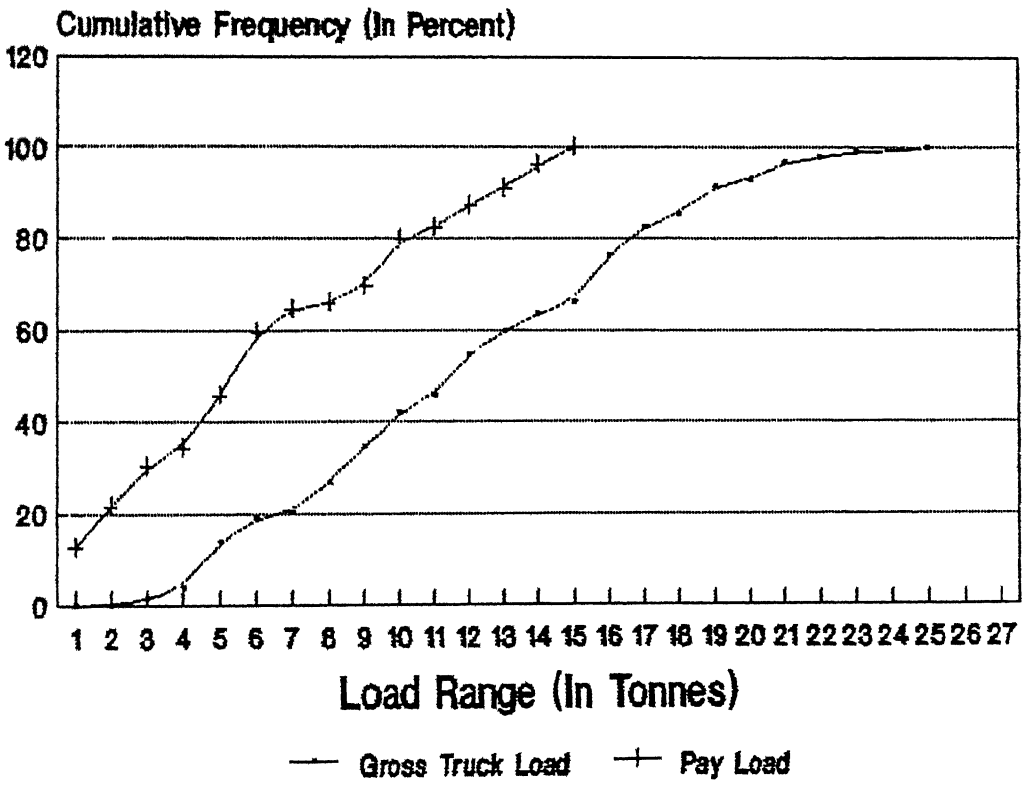
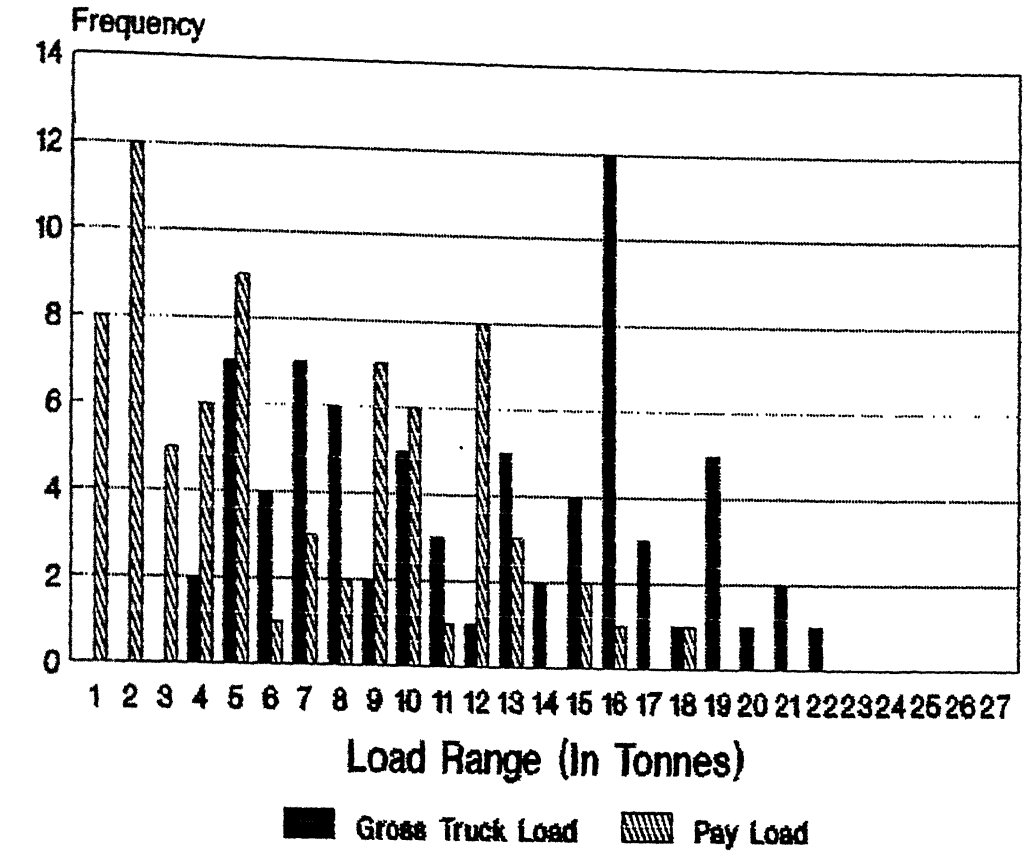


FIG. 4.6 DISTRIBUTION OF TRUCK LOADS AT G.A.W.S. (1)



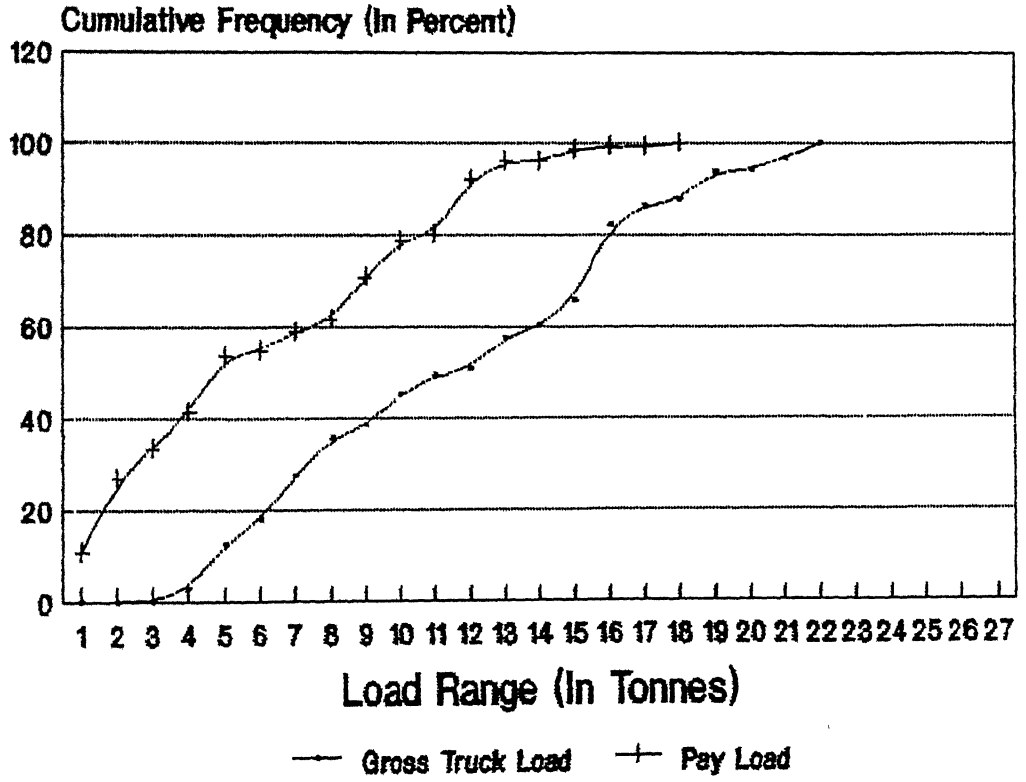
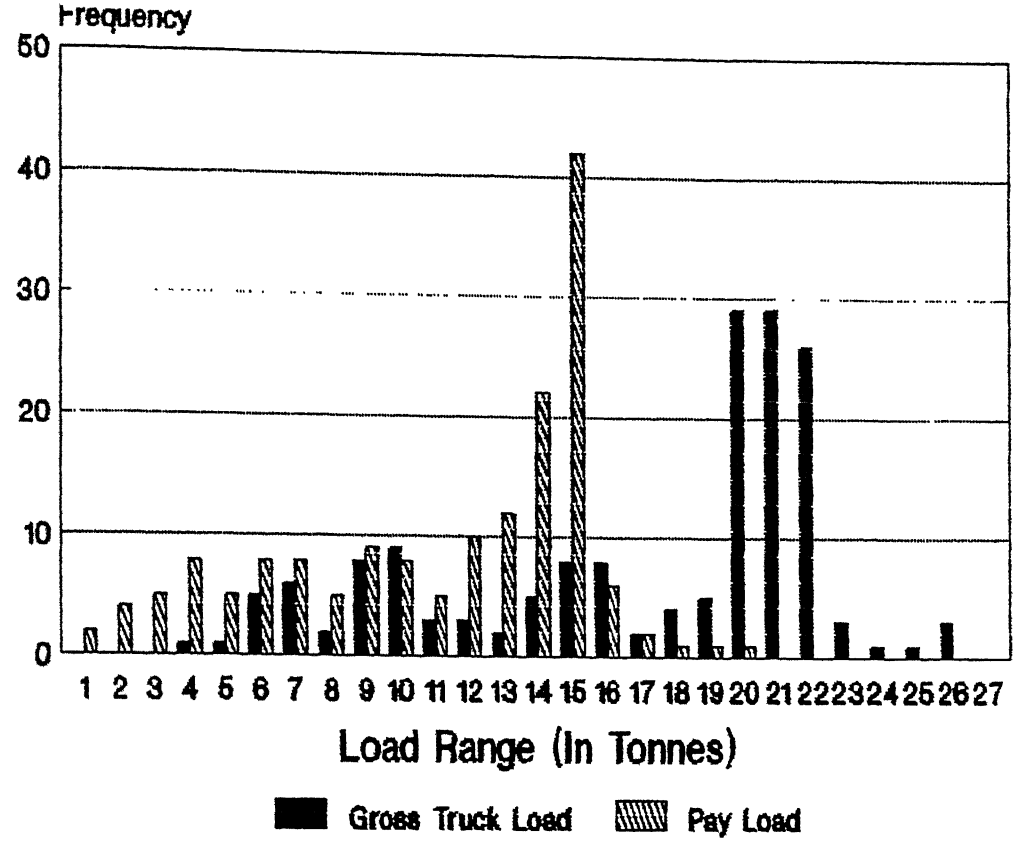


FIG. 4.7 DISTRIBUTION OF TRUCK LOADS AT G.A.W.S. (2)



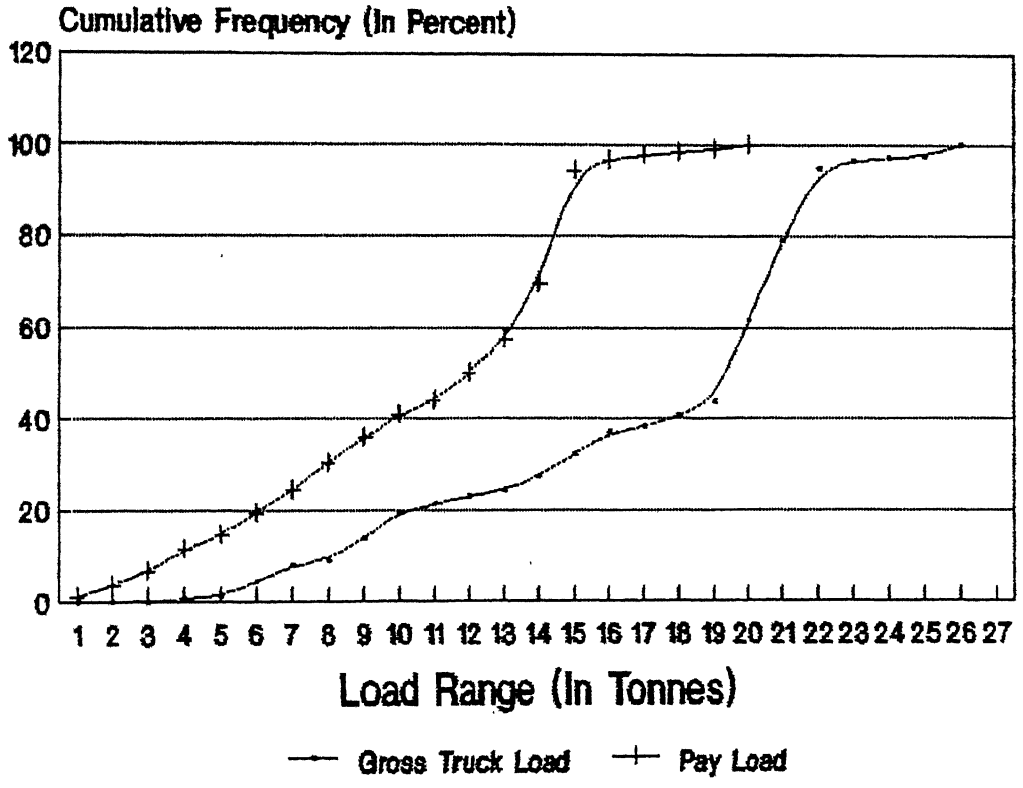


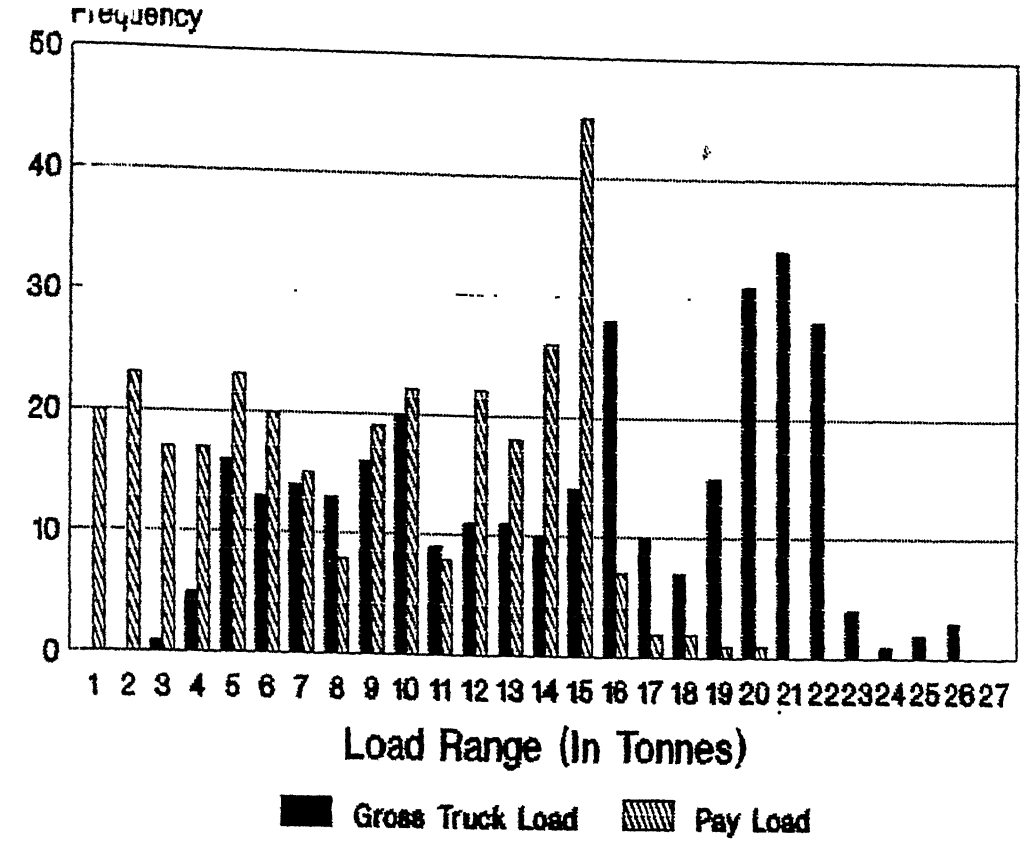
FIG. 4.8 DISTRIBUTION OF TRUCK LOADS AT G.A.W.S. (3)

Weighing Stations	Nos.	Gross Truck Load			Pay Load		
		Range (In Tones)	Mean	S.D.	Range (In Tones)	Mean	S.D.
G.A.W.S (1)	77	15-16	12.75	5.03	5-6	6.87	4.07
G.A.W.S (2)	75	16-17	12.74	5.33	10-11	7.06	4.45
G.A.W.S.(3)	164	20-23	17.76	5.40	14-16	11.73	4.39
All Stations (Combined)	316	21-23	15.29	5.88	15-16	9.44	4.94

Out of 77 (n) observations taken, the mean for gross load and pay load is found to be 12.75 and 6.87 respectively. Similarly standard deviation for gross loads and pay loads is found to be 5.027 and 4.071 respectively.

Figure 4.8 shows that for GAWS-2, there is a predominance of trucks having gross load range between 16 to 17 tones and pay load range between 10 to 11 tones. This represents a higher load range than GAWS-1. Out of 75 observations (n), the mean values for gross loads and pay loads are 12.74 and 7.06, similarly values for standard deviation are 5.336 and 4.446 respectively.

Figure 4.9 shows that for GAWS-3, threr is a majority of trucks having gross load range between 20 to 23 tones and pay load range between 14 to 16 tones. This reveals that this weighing station deals mainly over loaded trucks. Out of 164 observations (n), the mean values for gross loads and pay loads are 17.756 and 11.73, similarly standard deviation values are 5.401 and 4.395 respectively.



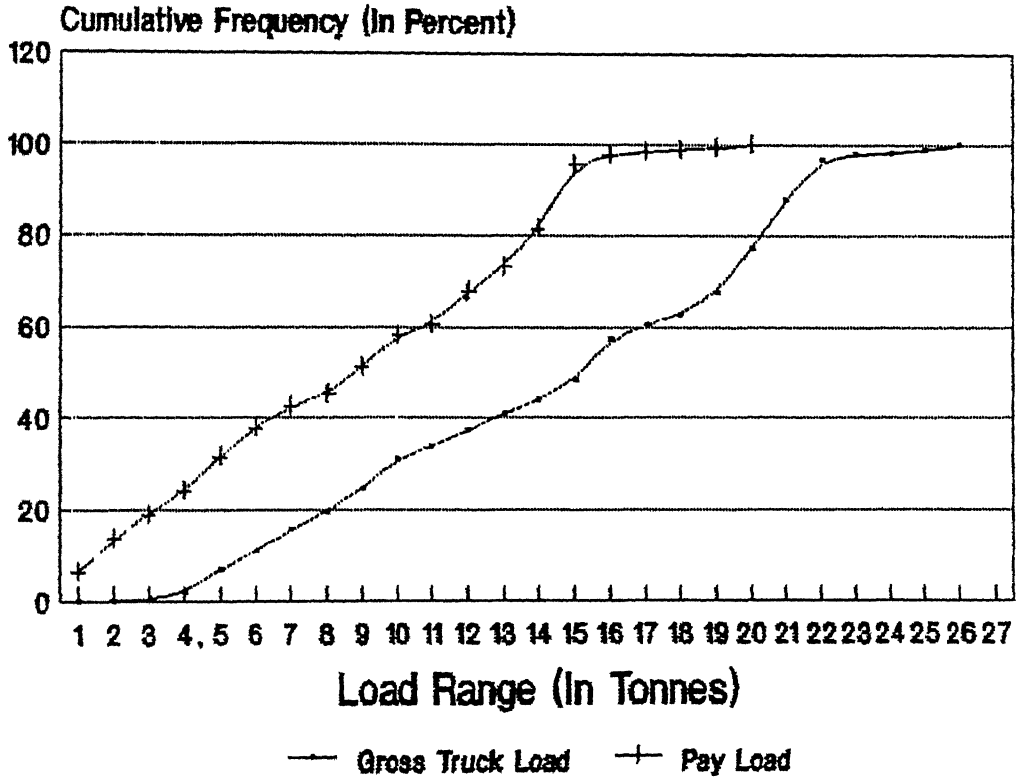


FIG. 4.9 DISTRIBUTION OF TRUCK LOADS FOR ALL WEIGHING STATIONS

A calculation for all the weighing stations (combined) has also been done and shown in Figure 4.9. Out of 316 total observations (n), the mean values for gross loads and pay loads are 15.290 and 9.44, similarly standard deviation values are 5.883 and 4.943 respectively.

Based on above analysis, it is suggested that the computation of the repetitions of the equivalent single wheel load (4000 Kgs as per IRC standards) must be considered for the distribution patterns of the truck loads. The design of the pavement structures based on those repetitions will be more rational.

4.7. CALIBRATION OF MODEL FOR FUTURE PREDICTION

There has been relatively greater work done in the area of inter-city trade demands. Some of the models based on concepts of urban travel demand forecasting have been applied to inter-city freight transport. The quantities and the types of commodities generated in a region are related to characteristics of the industries located there and to the population in case of attraction of goods for final consumption. These flows can be distributed by Gravity type models using freight transport rates and level of service.

Aggregate direct demand models accomplished, trip generation, distribution and modal split functions simultaneously. These models are further differentiated by trip purpose and employ as observation data on geographical aggregates. The Abstract mode model represents a typical Direct

demand model. An Abstract mode as characterised by the value of several variables that affect the desirability of the modes service. In addition to socio-economic and attraction variables, it employs as explanatory variables in the model for each mode, the travel time and the cost of all modes. In this way it measures the direct and cross modal effects of attributes of each model. The general form of model is given below (Jason C.Yu)

$$T_{ij}^{m} = a\, P_i^b\, P_j^c\, Q_i^d\, Q_j^e\, f\,(t_{ij}^{m})\, f\,(Z_{ij}^{m})\, f\,(w_{ij}^{m})$$

Where

T_{ij}^{m} = Trip inter change between Zone 'i' and Zone 'j' by mode 'm'.

P, Q = Measures of intensities of activities in Zone 'i' and Zone 'j' (Population, Employment etc).

t_{ij}^{m} = Relative travel time by mode 'm' between Zone 'i' and Zone 'j'.

Z_{ij}^{m} = Relative travel costs by mode 'm' in between Zone 'i' and Zone 'j'.

w_{ij}^{m} = Relative frequency of service and /or reliability by mode 'm' in between Zone 'i' and Zone 'j'.

a,b,c,d,e = Constants.

In the present study as the scope was restricted only to estimation of inter-city goods movement on roads by trucks, a following form of Gravity model was tested.

$$t_{ij} = p_i \frac{a_j * (d_{ij})}{\Sigma a_j * (d_{ij})^n}$$

Where

t_{ij} = Total number of trips produced between Zone 'i' and Zone 'j'.

p_i = Trips produced by Zone 'i'.

a_j = Trips attracted by Zone 'j'.

d_{ij} = Distance between Zone 'i' and Zone 'j'.

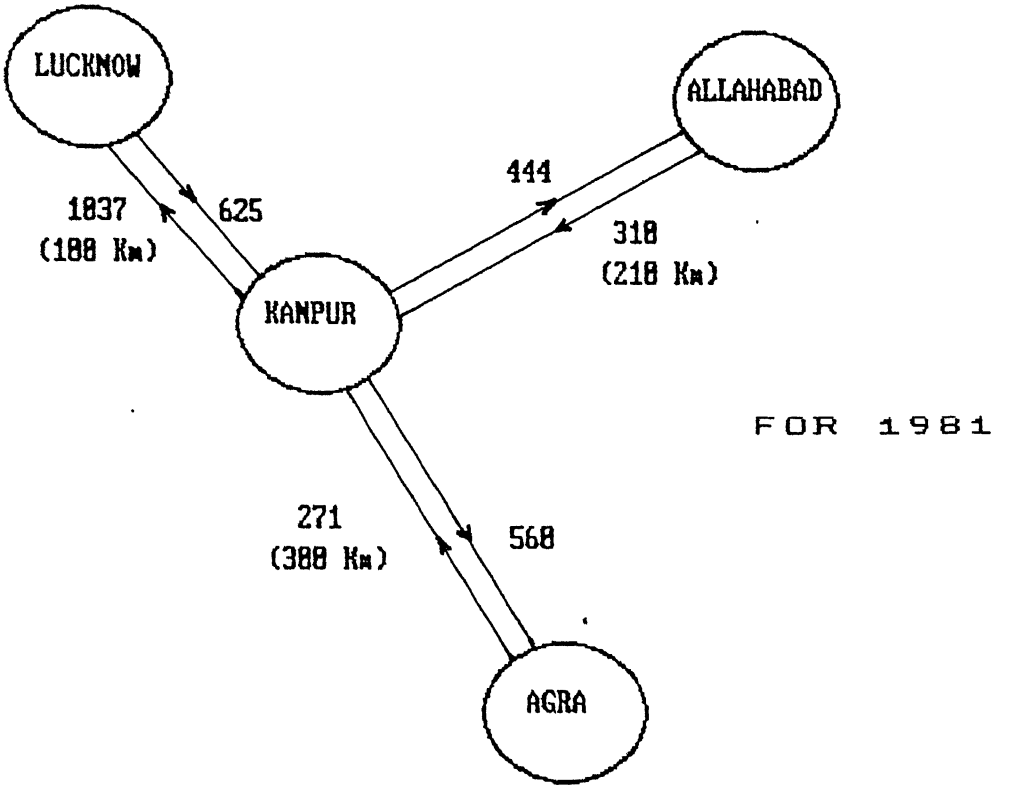
Based on the data available, it was observed that only six pairs of inter-city goods movement by trucks from/to Allahabad, Lucknow and Agra. Besides Kanpur, Lucknow, Agra and Allahabad are the other three important cities of the state of Uttar Pradesh and they are connected to Kanpur through National Highways.

The observed inter-city trucks movement for these cities as recorded for 1981 and for 1991 are given in Table 4.9 and Figure 4.10. Using the standard calibration procedures, the model coefficients (n) was estimated for the data of 1981. The calibrated value of 'n' was found to be 0.01. Using this value, the demand was estimated for the year 1992 for which the actual data is also available. A comparison of the observed and estimated values of inter-city truck movement for the year 1992 are presented below :-

TABLE 4.9

INTER CITY GOODS MOVEMENT FROM KANPUR
TO
AGRA, ALLAHABAD AND LUCKNOW

TO ⟶ / FROM ↴	KANPUR	ALLAHABAD	AGRA	LUCKNOW
FOR 1981				
KANPUR	–	444	271	1037
ALLAHABAD	560	–	–	–
AGRA	310	–	–	–
LUCKNOW	625	–	–	–
TOTAL	1495	444	271	1037
GRAND TOTAL = 1495 + 444 + 271 + 1037 = 3047				
FOR 1991				
KANPUR	–	1115	984	1337
ALLAHABAD	874	–	–	–
AGRA	1450	–	–	–
LUCKNOW	1537	–	–	–
TOTAL	3861	1115	984	1337
GRAND TOTAL = 3861 + 1115 + 984 + 1337 = 7297				



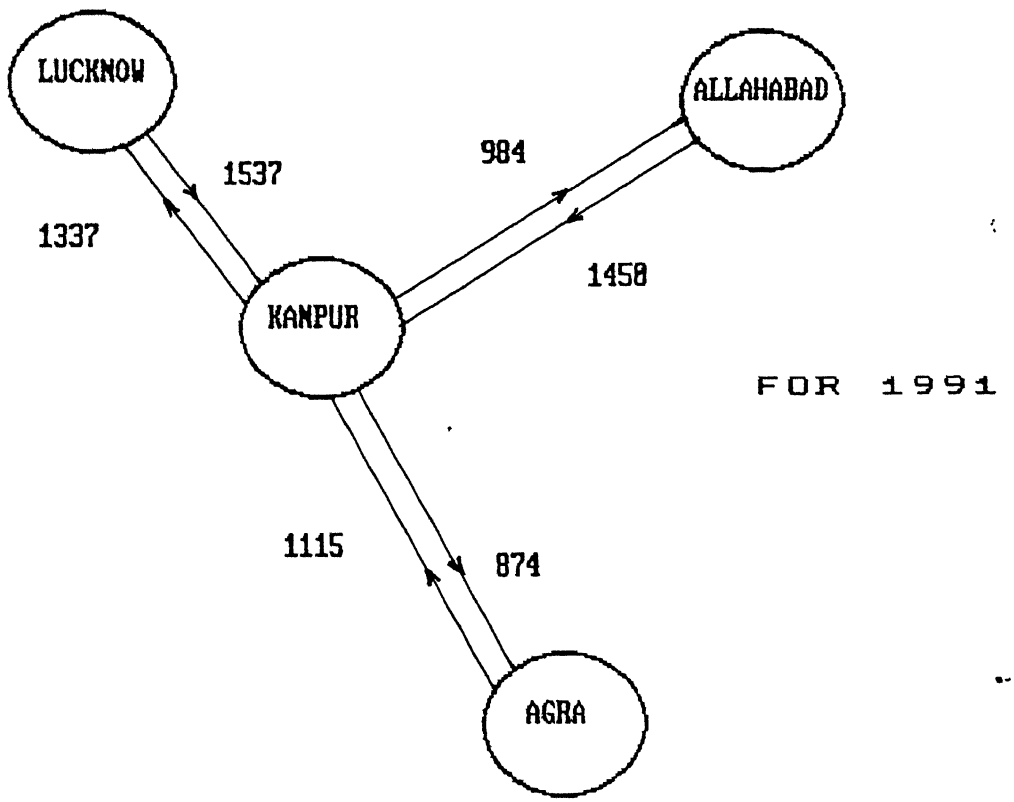


Fig. 4.18 INTERCITY GOODS MOVEMENT FROM\TO KANPUR AND ALLAHABAD,

OBSERVED DATA

From \ To	Kanpur	Agra	Allahabad	Lucknow
Kanpur	0	1518	2190	2916
Agra	930	0	*	*
Allahabad	1608	*	0	*
Lucknow	2310	*	*	0

ESTIMATED DATA

From \ To	Kanpur	Agra	Allahabad	Lucknow
Kanpur	0	1527	2195	2902
Agra	936	0	*	*
Allahabad	1613	*	0	*
Lucknow	2299	*	*	0

(* indicates unknown values)

Due to various constraints one is not very confident about the future prediction when only very few variables are being considered. The production and attraction of the goods truck traffic can be co-related with various socio-economic variables for the cities of Lucknow, Allahabad and Agra. This model could be taken as a starting point and there is a further scope for improvements.

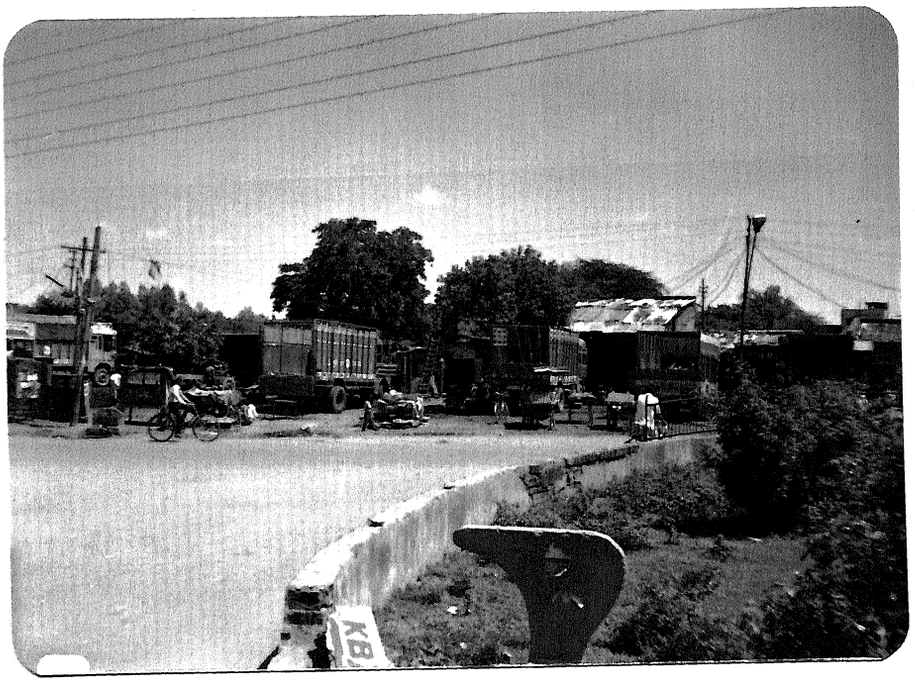
4.8. CONCLUSION

The above findings reveal the fact that trucks are having massive share(in percent) among all other modes of

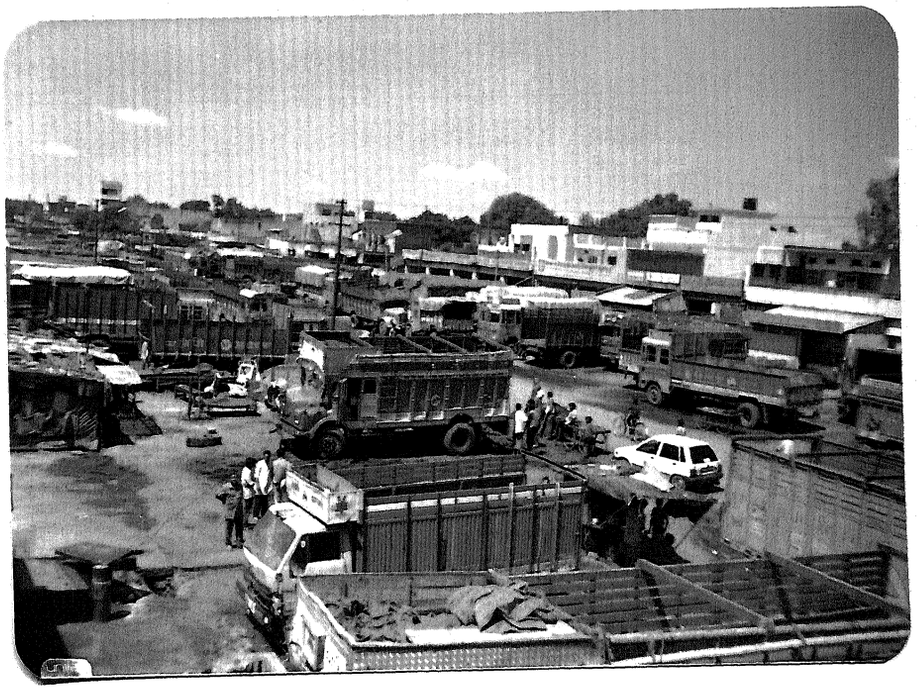
vehicles. Growth rate of trucks with time and population gives alarming results,presents confusing and deteriorating condition in the future loading patterns of truck loads, give amazing results of overloading and discloses the fact of crust failure on our main arterial. The above results caution from the tremendous commercial pressure and goods vehicular flow in near future which demands for proper concern and serious action against the person for their defiance of the Motor Vehicle Rules.

PHOTOGRAPH NO. 1 A PHOTOGRAPH SHOWING ROAD SIDE TRUCK PARKING

PHOTOGRAPH NO. 2 A PHOTOGRAPH SHOWING FLOATING TYPE ENCROACHMENT ON A HIGHWAY



PHOTOGRAPH NO. 3 A PHOTOGRAPH SHOWING TRUCK MAINTENENCE ACTIVITIES AT AN INTERSECTION



PHOTOGRAPH NO. 4 A VIEW OF TRANSPORT NAGAR

PHOTOGRAPH NO. 5 A PHOTOGRAPH SHOWING DETERIORATED CONDITION OF HIGHWAY DUE TO OVER LOADED TRUCKS AND ROAD SIDE ACTIVITIES

PHOTOGRAPH NO. 6 A VIEW OF OVER LOADED TRUCKS

5. REMEDIAL MEASURES TO IMPROVE TRAFFIC CONDITIONS

5.1 INTRODUCTION

The growth in the number of motor vehicles and their speed has far out paced the improvements to the road and other traffic facilities. The net consequence has been traffic congestion and traffic fatalities. The mismanaged trucking activities in the city further confounds the transportation problems. In the last decade the problem has been assuming menacing proportions . Generally the factors which contributes directly to such an event or problems are -

The Road

The Vehicle and

The Road user.

The inadequate road design, road space, and deteriorated road surface conditions, certainly are the major factors responsible for unsmooth flow, traffic congestion and traffic hazardous on the city roads.

Apart from above, improper vehicle design for trucks (ie. poor maneuverability), its poor maintenance, and over loading, makes the vehicle unfit for safe and convenient driving.

Similarly, the last factor responsible is the erroneous behaviour of road user i.e. agency which is involved in availing the benefits of the road system. It can be catagorised into two groups.

(i) Persons, involved in moving from one place to another i.e. drivers, passengers & pedestrians.

(ii) Persons, involved in road side activities ie. shop keepers, encroachers, & parked vehicles.

The rough and hazardous movement of trucks and other commercial vehicles, unpredictable behaviour of pedestrians, un-systematic vehicle parking, haphazard and irregular shopping activities and non-traffic uses of the road sides cause severe road accidents as well as jamming and delays in the smoother flow of the traffic.

5.2 PROCEDURE FOR PLANNING OF REMEDIAL MEASURES

For planning of the remedial measures of the road and goods traffic system, the following procedure was adopted.

(i) Preparation of the road network, primarily used by the goods vehicle and cordoning of the network.

(ii) Identification of critical intersections, stretches and accident prone spots etc. which cause problems of traffic jamming and accidents. This work was carried out by moving over the road network during peak periods and recording the characteristics of road and traffic operations.

(iii) Study of traffic volume and turning movements at the identified critical locations. These help in designing the control measures.

(iv) Forecast of the goods traffic for the year 2001, in the light of the present and past data.

(v) Detailed examination of the traffic flow characteristics as existing and likely to be for future.

(vi) Generation of various alternatives for short term and long term improvements of the road/traffic system.

(vii) Evaluation of the above alternatives with respect to feasibility of implementation and resource available.

(viii) Selection of the various short term and long term measures.

5.3 SHORT TERM MEASURES

In order to proceed in solving the traffic problems, which are urgent in nature and are less time and funds consuming, planning is to be done on short term basis. This will involve all the measures, connected with the traffic engineering, traffic enforcement and traffic education for creating healthy atmosphere for the movement of goods traffic.

5.3.1 TRAFFIC ENGINEERING MEASURES

5.3.1.1 IMPROVEMENT OF ROAD STRETCHES/INTERSECTIONS

To stream line the goods traffic movement in Kanpur, road stretches catering mainly truck traffic should be improved and intersections fall on these stretches should be developed in their geometrics (Fig. 5.1).

* After comparing the high volume of trucks (over 3500 trucks per day) and highest accident rates (over 22 percent) (IRC, 1979), road stretch between Kalyanpur to Rawatpur intersection needs immediate attention. This stretch is only 2 lane wide in most of its length with improper shoulders. It is over utilised therefore provision for at least 4 lane wide

divided carriage way with 2 mt wide side patries, should be made for smoother and safe movement of trucks. G.T. Road should be properly illuminated in the night and provision for traffic control devices should be made at different curves and small intersection points or points of important institutions.

* Kalyanpur intersection should be designed in its geometrics in such a way that it may channelise and separate local and turning movement with straight movement. This will avoid the confusion and accident possibilities at the intersection.

* Gurudeo palace intersection has the provision of channelisers but provision for signal or day/night blinkers should be made.

* Stretch between Naubasta to Afim Kothi intersection, Tat mill intersection to Kidwai Nagar intersection and main road stretch inside the Transport Nagar area i.e. from Transport Nagar intersection to Juhi canal intersection, are over utilised and the road has not been widened to its full capacity and adequate strength.

These road stretches should be divided and widened to at least 4 to 6 lanes with a provision of sufficient road side parking.

* Bye pass road, from Yashoda Nagar to Naubasta intersection, is only two lane wide and is highly utilised (4572 trucks per day). Because of straight road portion, improper and insufficient illumination in the night, this stretch presents second highest accident rate in Kanpur. (IRC, 1979)

This stretch on Kanpur bye pass should be paved to at least one lane more for the provision of proper shoulders. Sufficient illumination in night on complete bye pass and day/night blinkers should be provided at different unsignalised and small junctions.

* Intersections like Bara Devi, Kidwai Nagar, have been geometrically improved but they are lacking in signalisation. Similarly intersections like Naubasta, Yashoda Nagar and Transport Nagar should be improved in their geometrics and traffic control devices should be placed at the intersections.

* Transport Nagar inside road needs technically designed parking and shelter places for the truck traffic which will decongest the Transport Nagar inside and will provide a healthy environment for goods transport with in Transport Nagar area.

5.3.1.2 CONSTRUCTION OF MISSING LINKS

To ensure the proper diversion of the trucks, some of the missing links should be developed. These are as follows :

* Between Kalyanpur Station (west signal) crossing to Shivli road :- This link will help us in diverting around 1400 trucks from Furrukhabad side on G.T. road towards city which ultimately will lead to decongest the G.T. road with in the city and avoid majority of fatal accidents.

* Between Dada Nagar intersection to Bye pass road :- This link is very important in solving the turning problem at C.T.I. canal crossing. The development of this link

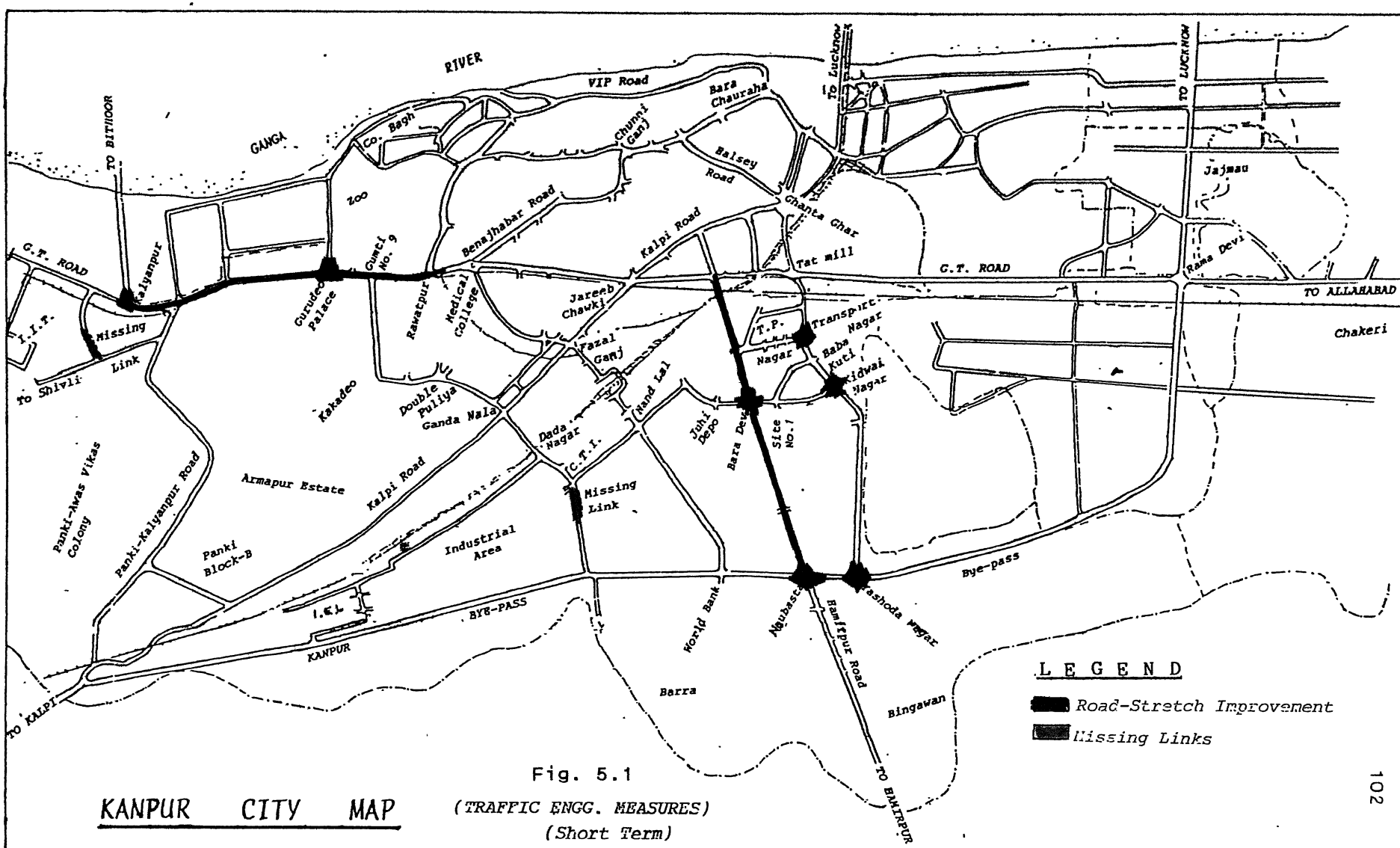


Fig. 5.1

KANPUR CITY MAP (TRAFFIC ENGG. MEASURES) (Short Term)

will smoothen the traffic flow and avoid the unnecessary U-turn of trucks and other vehicles along Dada Nagar canal. If we divert the trucks from Gumti No. 9 crossing on G.T. road, this link will help us to shorten the distance and will provide the direct approach to the goods vehicle, having business in south west Kanpur or industrial area of Kanpur.

* Between Panki Kalyanpur road and Kalpi road :- Panki - Kalyanpur road is having no. of links with the Kalpi road. All the connecting links except one are through the residential colonies, so it is hazardous and unsafe if we divert the truck traffic on these roads. One link which directly connects Kalpi road has a railway crossing enroute on which the frequency of trains is alarmingly high. This works as a potential obstruction in routing the trucks to Kalpi road. Panki B block road should be improved in such a way that it withstands the heavy trucks volume and is also safe for local movement. Both the ends should be geometrically designed with proper informations of truck diversion. This line will help us in diverting the trucks from Panki-Kalyanpur road crossing at Kalyanpur, to Kalpi road and Bye pass.

5.3.2 TRAFFIC MANAGEMENT MEASURES

In order to check the congestion level and road accidents from traffic management point of view, improper enforcement and lack of traffic sense have been the main factors. To solve this problem on short term basis, strict enforcement of one - way system, restriction of vehicles on certain corridors,

enforcement on proper vehicle parking, removal of road side non - traffic uses and illegal commercialisation, is needed. If these things are enforced, checked and paid utmost attention, we may ensure healthier and safer movement of the people and goods in near future (Fig. 5.2).

5.3.2.1 RESTRICTION ON HEAVY VEHICLES

In the present conditions, roads like V.I.P. road, Mall road, Benajhabar road and other roads which fall on the north of G.T. road and between Ghanta ghar Rly. Station on East and Zoo on West side, have different temporal restrictions for goods vehicles. V.I.P. road & Mall Road are completely banned for truck traffic at any hour. Main Roads fall on southern side of G.T. road and different National/State highways do not have any restriction of trucks at any hour. We see that south Kanpur mainly deals with the commercial and industrial activities while Ghanta ghar area in the north. Majority of the fatal accidents are on National/State highways or on roads in south Kanpur area (IRC, 1979). So restriction of truck movement and speed restriction is needed on certain parts of the National/State highways and other roads catering mainly truck traffic are mentioned below :-

* Road stretch between Kalyanpur crossing to Ramadevi intersection on G.T. road has been very problematic and unsafe from traffic point of view. This stretch needs complete ban on the truck traffic. In order to divert trucks from this

part of G.T. road, five alternatives are being suggested as follows :-

(i) From Kalyanpur station (east signal) crossing to Panki Kalyanpur road - Panki (B-Block) road- Kalpi road - Panki flyover - bye pass road to Ramadevi intersection (for both directions) (Fig. 5.1)

(ii) From Kalyanpur station (west signal) crossing to missing link to shivli road - Panki Kalyanpur road intersection (for one direction movement) and will take same route as above (i) from Panki Kalyanpur road to Kalpi road and bye pass. For vehicles from the other directions, these will move between Shivali road intersection to Kalyanpur railway crossing and then will take left turn towards Furrukhabad side. This will make circular route between both the signal crossings and Shivli road (Fig. 5.2).

(iii) From Kalyanpur crossing to Gurudeo palace crossing - Gumti No. 9 crossing - Kakadeo double road - Double pulia - Ganda Nala intersection - C.T.I. intersection - Missing link - Bye pass and to Ramadevi intersection for both the directions.

(iv) This route is same as (iii) except from Ganda Nala intersection to Kalpi road - Panki flyover - Bye pass and to Ramadevi intersection.

(v) This is same as (iii) and (iv) above except from Ganda Nala intersection - Dada Nagar intersection

- Industrial area main road - Thums-up crossing - Lohia scooter - Bye pass and to Ramadevi intersection.

From the above five alternatives (i) and (ii) are more feasible with minor investments for the construction of missing links. These two alternative road links will avoid around 2500 trucks per day from the majority of residential colonies and an unsafe road stretch between Kalyanpur crossing to Gumti No. 9 on G.T. road and will add the same number of trucks and distribute in different major arterials of south Kanpur.

* Kalpi road and Hamirpur road do not show substantial road accidents therefore these roads should have maximum speed limit controls within the city limit.

* Road stretches from Bara Devi to Kidwai Nagar intersection, from Kidwai Nagar to Tat Mill intersection, from Bara Devi to Afim Kothi intersection, from C.T.I. crossing to Nand Lal intersection, from Nand Lal intersection to Bara Devi intersection, from Tat Mill intersection to Ghanta Ghar area and from Parade to Ghantaghar intersection should have temporal restrictions to avoid the different peak hours of the day on each road. It will be safe for the other traffic and helpful for traffic management, if trucks are completely banned during day hours i.e. from 9 AM to 9 PM.

* Bye pass road was initially developed at the out skirt of the city but now a days it is surrounded by different residential colonies throughout its length within the city. So

cautionary boards and speed limit controls should be provided to restrict the speed of trucks.

5.3.2.2 TRAFFIC ENFORCEMENT FOR ONE-WAY TRAFFIC ON CERTAIN LINKS

Kanpur city is having only one one-way system i.e. Bakarmandi - Bajaria one-way system. This is mainly for light vehicles. There is not a single road stretch which is one-way for heavy vehicles.

Besides other enforcement rules, traffic can be regulated and congestion can be avoided by making certain roads one-way for trucks. These roads can be listed as follows -

* Stretch between Site No. 1 intersection to Baba Kuti intersection.

* Between parallel roads i.e. from Tat Mill to Kidwai Nagar intersection and from Afim Kothi to Bara Devi intersection.

* Between parallel roads i.e. from Bara Devi to Kidwai Nagar intersection and from Naubasta to Yashoada Nagar intersection on bye-pass.

* Between two parallel main roads inside the Transport Nagar area, from Juhi Canal to Transport Nagar intersection.

* Between Shivli road to Kalyanpur east and west signal railway crossings.

The above arrangement will divide the truck load on these stretches which will lead to optimum utilisation of the road space available for traffic in near future.

5.3.2.3 PARKING RESTRICTIONS

Road side non-systematic parking of trucks, creates two types of problems against the smoother flow of the traffic.

(i) It occupies more space what it should be.

(ii) It creates illegal repair/maintenance units, which ultimately convert into semi-permanent type encroachment along the road sides.

To avoid such things there is need for systematic parking on certain parts of the roads and total restrictions on parking on certain roads. To save our road space and maximise the effective road width available for traffic, following type of roads should have different type of parking restrictions.

(i) Road stretch from Naubasta intersection to Yashoda Nagar intersection should be completely banned for parking.

(ii) Road stretch from Baradevi intersection to Kidwai Nagar intersection should also be banned for truck parking. Provision for truck parking should be made inside the fruit market.

(iii) Well designed parking provisions should be made inside the Transport Nagar area which is essential for loading / unloading and repair facilities of trucks.

(iv) All the intersections around Transport Nagar area should be free from any type of vehicle parking within hundred meter range on all sides.

5.3.2.4 ENCROACHMENT REMOVAL

There are four types of encroachment tendencies :-

(i) Floating type encroachment.

(ii) Shop extensions.

(iii) Semi permanent or temporary sheds.

(iv) Permanent type having RB/RCC slabs.

Majority of roads/crossings suffer mainly from first two type of encroachment tendencies. Hawkers on the road sides and slow and steady conversion of land use from residential to semi - commercial, lead to a well established commercial strip in future.

Secondly, some of our major roads, mainly National and State highways, are succumbed by semi-permanent and permanent type of encroachments. This type of encroachment needs massive anti - encroachment drives equipped with sufficient police and man power.

The above problem needs utmost priority and immediate attention for the redressal of the road system. To solve this, a well programmed anti - encroachment drive is needed on continuous basis for a long time. There should be some specific department which should be specifically made responsible to remove the encroachments and to guard the land against such activities. Municipal corporation bears this responsibility for the roads belonging to them but as we see that severe and massive encroachment is on the P.W.D. roads. P.W.D. does not have any power in their act to protect their land immediately without going into any litigations. This has been the reason for

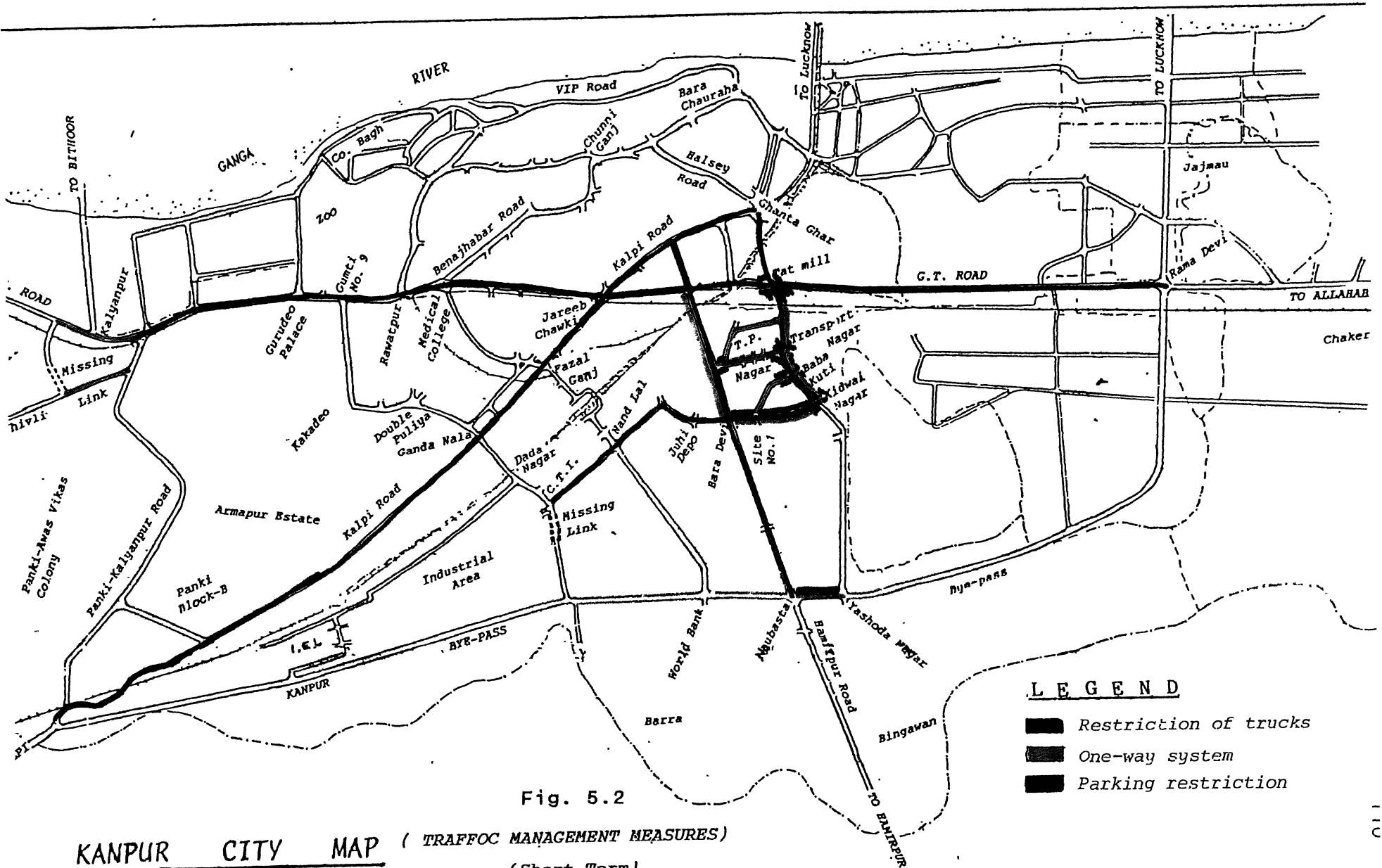


Fig. 5.2

KANPUR CITY MAP (TRAFFOC MANAGEMENT MEASURES)

(Short Term)

encroachers to grab the P.W.D. land. Therefore Municipal Corporation should also be held responsible to protect all land with in the city limits.

For shop extensions and for floating type encroachments, massive anti - encroachment drive will not be successful. There is an effective way to protect our land against such activities, is the financial penalties. If heavy financial penalty is imposed once in a day and wide publicity is made, then this will restrict such a tendency in near future.

5.3.3 TRAFFIC EDUCATION MEASURES

Traffic education measures mainly deal with the mental reformation and knowledge of the characteristics of the traffic, road system and its behaviour.

For short term education measures, mainly two types of activities are needed, both for the user and for the implementing body.

(i) Imparting knowledge about traffic flows and traffic rules and road characteristics by providing informatory, regulatory and mandatory sign boards.

(ii) By educating traffic constables and providing through certain written guide lines through them to truck drivers for safe and controlled driving.

5.4 LONG TERM MEASURES

Implementation of short term measures in solving the spot problems will not suffice in achieving the global objective

of healthier and safer movement of the traffic. Short term measures have money and time constrains. In order to attempt for solving the root cause of the transport problems in a bigger way, long term traffic engineering, traffic management and traffic education measures are needed. These measures involve capital intensive projects, which are for a longer time span. Therefore preparation and implementation of these should be continued along with short term measures (Fig. 5.3).

5.4.1 TRAFFIC ENGINEERING MEASURES

Growth in truck traffic has gone tremendously up in the recent past. The growth trend is alarming and needs immediate attention in terms of providing adequate terminal facilities for loading/unloading. Construction of new flyovers or increasing the capacity of the existing flyovers and provision for bye passing the trucks from the outer part of the city.

5.4.1.1 CONSTRUCTION OF NEW FLYOVERS

Diverting the traffic from Kalyanpur crossings may create problems of delay and confusion because of inadequate space at the crossing and high frequency of trains passing through this. Similarly medical college crossing and C.O.D. crossing on G.T. road create congestion and delays in truck movement by high frequency of trains and by inter-mixing of trucks with the light and local non-commercial vehicles. The above spots need new flyovers to divert trucks and to avoid it from inter-mixing with light vehicles. These flyovers are

proposed at

Kalyanpur Crossing

C.O.D. Crossing and

Medical College Crossing.

5.4.1.2 WIDENING OF EXISTING OVER BRIDGES

There is a very heavy north-south truck movement at Harris ganj bridge and Nayapul and likewise. east-west movement on G.T. road at Jhakarkati bridge. These bridges are in-sufficient to cater existing truck traffic. Therefore widening of over bridges is required to channelise and smoothen the goods movement mentioned below :-

i Nayapul,

ii Jhakar kati bridge,

iii Harris ganj bridge.

5.4.1.3 CONSTRUCTION OF A NEW BYE PASS.

Existing bye pass was constructed in early 70's to bye pass the through traffic from the outskirt of the city but due to tremendous growth in residential and commercial activities in south Kanpur, present bye pass has become well within the residential colonies. The inter-mixing of heavy goods traffic with the local light vehicles and no. of cross movements on present bye pass resulted into high frequency of fatal accidents. Due to above reasons there is need of new bye pass which should be connected with all the National and State highways passing through the city and placed at the outer periphery of the city.

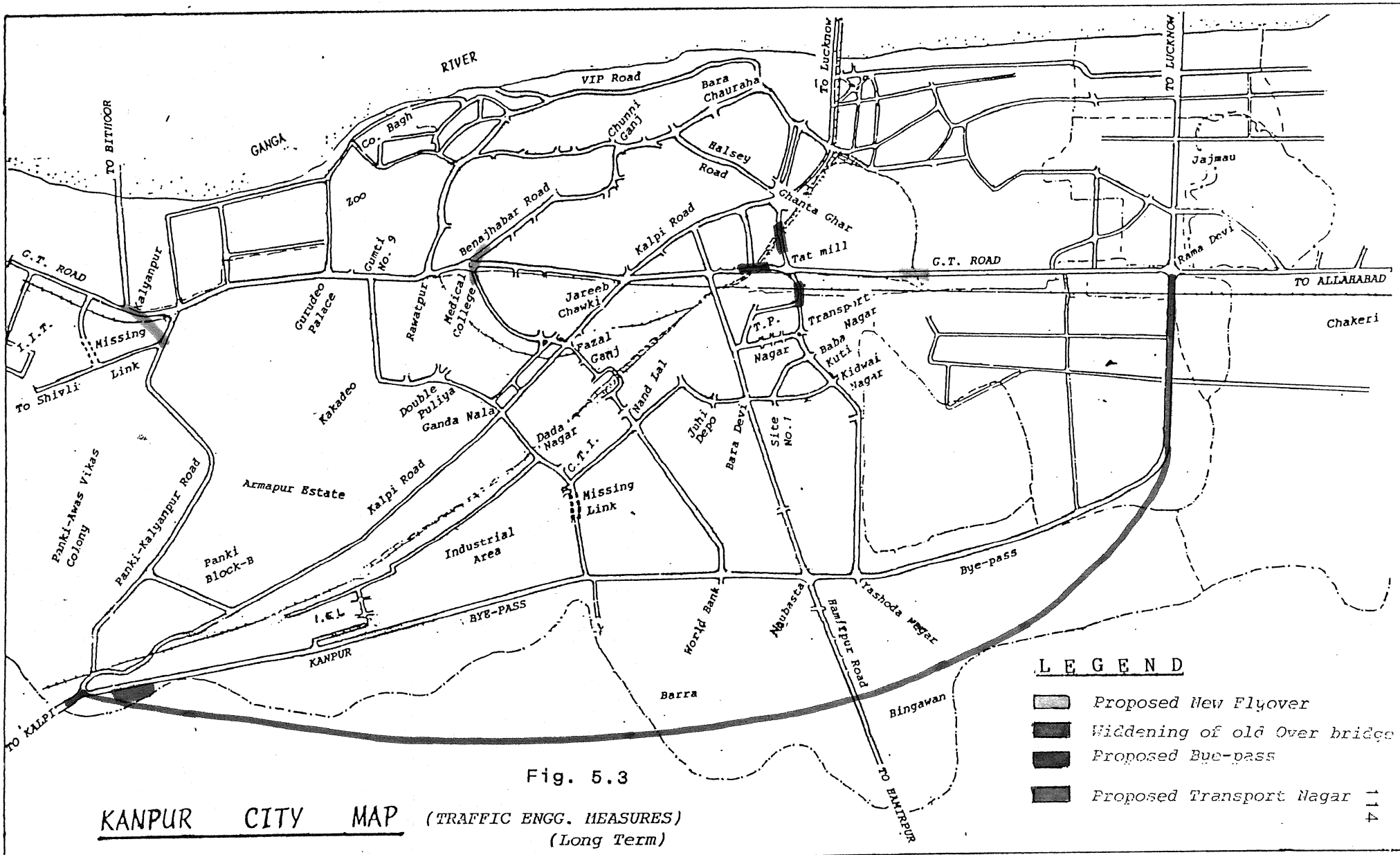


Fig. 5.3

KANPUR CITY MAP (TRAFFIC ENGG. MEASURES)
(Long Term)

To satisfy above need a new bye pass is proposed near Bhauti from Kalpi road connecting Bingawan on Hamirpur road and Rama Devi intersection on G.T. road.

5.4.1.4 CONSTRUCTION OF A NEW TRANSPORT NAGAR.

Initially a Transport Nagar was planned and constructed in south Kanpur nearer to the bye pass. This area was thinly populated and very few commercial centers were there. Since last 10 to 15 years, there found to be a tremendous growth in population and expansion in residential, commercial and industrial activities in the southern part of the Kanpur. This has surrounded present Transport Nagar by no. of different residential colonies and commercial centers which resulted into tremendous trucking activities and traffic load at the junctions and stretches nearby.

In order to avoid such problems in near future, a new Transport Nagar is needed. This should be placed in such a way that it should connect proposed bye pass and should be nearer to National and State highways. It is recommended to plan a new Transport Nagar at Bhauti (near proposed bye pass) which connects the present and proposed bye pass. New Transport Nagar should be provided with sufficient space for truck parking and other ancillary trucking activities.

5.4.2 TRAFFIC MANAGEMENT MEASURES

Short term management measures are useful for immediate traffic management and spot control measures. But for global

angle and for long term management, different managerial policies are to be framed and adopted in order to release the congestion level and safety of the traffic in near future. Some of the policies are mentioned below :-

(i) Our present traffic controlling staff is inadequate to control the existing situations. Previous studies reveal the fact that about 30 percent of the required number of police personnel are employed on the junctions. Traffic police in Kanpur do not have proper communication systems and other related electronic equipments such as walky - talky, wireless sets, motor cycles, T.V. video photography at the junction points etc. Therefore adequate traffic management hands and sufficient no. of traffic police personnel, equipped with latest equipments, electronic devices and techniques should be employed.

(ii) Relevant global traffic policies should be made and a Transport authority should be established for enforcing the same for transportation of goods and formulating policies conducive to healthier and safe traffic movement.

5.4.3 TRAFFIC EDUCATION MEASURES

Long term traffic education measures are needed in order to develop traffic sense to the persons involved in using the road system and to the persons involved in controlling and implementing the rules for safe movement of traffic. Some of the

policies for educating the concerned personnel are -

(i) Road Transportation Authority should incorporate in its licensing procedure, imparting of certain requisite knowledge of traffic and motor vehicle rules.

(ii) Traffic police personnel and drivers should have mental exposure to such activity where they can have a feel of different type of intersections, road signs and other knowledge important for the safe movement on the roads.

6. SUMMERY AND CONCLUSION

6.1 INTRODUCTION

Kanpur, one of the largest metropolis of North India, is the largest city in the State of Uttar Pradesh. Since its origin, Kanpur has become vitally important to the State and Nation because of considerable commercial and economic influences. Massive growth in trade affairs and population density, has plagued the transport system of Kanpur. The city road network system has succumbed due to encroachment, un-systematic on-street parking and inter-mixing of slow with fast and heavy with light modes of transport, resulted into extremely low travel speed and sub standard level of service.

Acute traffic problems and the higher rate of accidents on the main arterial and intersections in Kanpur are due to

- Defiance of Master Plan recommendations,
- Road side encroachments,
- Un-systematic road side parking and shortage of off-street parking places,
- Lack of traffic control devices and their effectiveness,
- Non-traffic uses of the road sides/pedestrian paths and
- Predominance of over loaded goods vehicles.

The above reasons are responsible for massive road accidents, lesser effective use of road space available for traffic, unsafe movement of pedestrians and vehicles, un-planned and un-managed growth of city, deteriorated conditions of the roads and intersections and mis-directed and inferior mental reformation of the residents of Kanpur.

In the present study, it is attempted to have a detailed study on existing pattern of truck movement through data collection at different locations, loading and unloading patterns, growth of inter-city and intra-city truck movement and analyse the problems in Transport Nagar area. In the light of above analysis various remedial measures, for the management of the goods transport in the city, are proposed.

The scope of this study involved study of different parameters and aspects of road system, characteristics of traffic, identification of problematic conditions and spots and their possible solutions for the redressal of the deteriorated and hazardous goods movement in Kanpur City.

6.2 FIELDS STUDIES FOR GOODS MOVEMENT

6.2.1 METHODOLOGY

To asses the existing traffic conditions for goods vehicles, the following methodology is adopted in this study :-

(i) Identification of road network intersections.

(ii) Study the characteristics of various intersections and road stretches with their volumetric surveys for goods vehicles.

(iii) Inventory of roads of Transport Nagar area with flow parameters.

(iv) Study the loading patterns of goods traffic.

6.2.1.1 IDENTIFICATION OF THE ROAD NETWORK AND CRITICAL INTERSECTIONS

City was divided into three different cordons, as per the characteristics of traffic, population density and types of modes mainly deal with. Sixteen different intersections were identified and mentioned below :

Five intersections, Rama Devi, Yashoda Nagar, Naubasta, World Bank and Kalyanpur, are placed at outer cordon while rest of eleven intersections as Medical College, Tat Mill, Transport Nagar, Baba Kuti, Kidwai Nagar, Site No. 1, Bara Devi, Juhi Depot, Nand Lal, Ganda Nala and Fazal Ganj intersections are situated between intermediate and outer cordon of the city. Intersections placed on outer cordon mainly deal with inter-city goods movement while others deal with intra-city and local movements of commercial and other vehicles.

6.2.1.2 TRAFFIC VOLUME SURVEY AND ITS ANALYSIS

Traffic flow pattern at all the sixteen intersections is studied. Traffic volume counts are being done for four hours durations in the morning as well as in the evenings. To get the actual intensity of un-interrupted goods vehicles, morning four hourly truck volumes were taken for our analysis purposes. Analysis is done only for truck traffic as per the scope of this study.

Analysis show that intersections like Naubasta, Yashoda Nagar, Transport Nagar and Tat Mill possess heavy turning movements (60 - 90 percent of the total truck volume at the intersection). It also reveals that road stretches between Tat

Mill to Transport Nagar intersection and Yashoda Nagar to Naubasta intersection are heavily loaded and over utilised by truck traffic, thus causing traffic congestion and substantial road accidents. The Peak Hour Factor (P.H.F.) for critical intersections was also calculated and the values as derived is ranging between 0.828 to 0.833.

6.3 STUDY OF GROWTH PATTERN AND FUTURE SCENARIO

Being an important city of North India, commercial trade coming in and going out from Kanpur, through five main arterial e.g. N.H. 25 (Lucknow, Gorakhpur and Kalpi, Delhi side), N.H. 2 (Allahabad side), S.H. 17 (Hamirpur side), S.H. 22 (Agra, Delhi side).

All the sixteen intersections are involved in catering the truck traffic for any of the above mentioned cities. Kanpur Municipal Corporation has surveyed some of these intersections in 1982-83. Values taken from 1982-83 data were compared with the present (1992-93) values of truck traffic and growth rate is determined. It varies between 8.91 percent to 20.89 percent. Observations revealed that intersections on bye-pass show greater variation in truck traffic than on other city roads.

Assuming the same (observed) growth rate for each intersections, trucks volume for the year 2001 was also determined. It shows that there would be tremendous pressure of goods vehicles mainly at Naubasta, Yashoda Nagar and Transport Nagar intersections in near future. This will lead to utter confusion, jamming and almost failure of the transport system in southern part of city. There is need of immediate attention for

the redressel of the transport problem to ward of the immensing collapse of the transport system in South Kanpur.

6.4 STUDY OF GOODS TRAFFIC IN TRANSPORT NAGAR AREA

Transport Nagar consists of one main link road and other cross roads at right angle to this. It is surrounded by four main arterial e.g. Kidwai Nagar - Bara Devi road, Baba Kuti - Juhi Canal road along east - west direction and Kidwai Nagar - Tat Mill road, Bara Devi - Juhi Canal road along north south direction.

To have a feel of flow parameters and characteristics of Transport Nagar area, travel time studies were carried out. Analysis showed that the running speed recorded is ranging between 14 to 36 km. per hour and the maximum concentration was recorded as 27 vehicles per km. between Transport Nagar to Juhi canal intersection.

The volumetric survey of truck traffic for the intersections around Transport Nagar (e.g. Yashoda Nagar, Kidwai Nagar, Bara Devi, Naubasta and Tat Mill) shows that 5412 trucks per day and 1248 trucks per day enter in the Transport Nagar area from southern and northern part of it respectively. The reason being that drivers want to ply on smoother and less time consuming routes rather than through a congested stretch.

The present location of Transport Nagar has now surrounded by many residential and commercial colonies. The irregular and inappropriate uses of road sides, tremendous commercial and goods vehicular pressures, therefore demands for the relocation of Transport Nagar.

6.5 STUDY OF INTER - CITY GOODS FLOW PATTERN

Major roads which are responsible for the inter-city freight transport in Kanpur are : New Lucknow road (NH 25), Kalpi Road (NH 2/25), G.T. Road (SH 22/NH 2), Old Lucknow Road and Hamirpur Road (SH 17). The locations used for taking volumetric survey in this study were the old octroi stations at each of the above mentioned roads. (Jajmau, Bhauti, Ganga Ghat, Kalyanpur, Ahirwan and Bingawan). Along with this attempt, three other agencies had already attempted to know the inter-city truck traffic in previous years e.g. Kanpur Municipal Corporation in 1982-83, Consulting Engineering Services (CES) in 1987-88, National Transportation Planning and Research Center (NATPAC) in 1990-91.

The above studies show that volume of trucks on roads show major share in comparison to other traffic. A total of 15774 trucks per day are recorded in comparison to only 6409 in 1982-83 and 9495 in 1987-88.

6.5.1 GROWTH IN INTER-CITY TRUCK TRAFFIC

Truck traffic for the years 1982-83, 1987-88, 1990-91 and 1992-93 are tabulated. The highest growth rate for incoming and out going truck traffic was found to be 12.97 percent and 10 percent for Ahirwan and Bhauti Octroi stations respectively. A Graph is plotted between year with incoming, outgoing and total truck traffic, the best fit equation was found to be of exponential in nature i.e.

$$T = \exp(a Y) \times c$$

'a' and 'c' are some constants.

where T denotes the truck volume and Y denotes the year. The Truck volume for the year 2001 is calculated and found to be 21137, 16324 and 34870 for incoming, outgoing and total traffic respectively.

A Graph is plotted between total number of trucks with population of the corresponding years. The best fit Equations are tried for linear and exponential patterns and are found to be of

$$T = a P + b$$

$$\text{and} \quad T = \exp (a - b P) \times c$$

nature respectively. The values of total truck volumes are calculated for the year 2001, are 23715, 26453for linear and exponential patterns respectively.

6.6 ANALYSIS OF TRUCK LOAD AND ITS ESTIMATION

Roads are designed as per the class - A loading of IRC and are resurfaced within the prescribed time limits. Even then we find surface failures. It is observed that generally over loaded trucks are responsible for the failure of the road surface. Therefore for proper design of the pavement, knowledge of the distribution of the axle load is essential. It was planned to record the Gross load and pay loads of trucks, as recorded for various Government Approved Weighing Stations (G.A.W.S.), located at different cordons of the city. A total of 316 number of trucks were recorded for three weighing stations in 24 hours. Different bar charts and graphs are plotted between frequency of trucks and load range for gross load and pay loads.

The distribution showed that different weighing stations possess different load range. Mean and standard

deviation values for all the weighing stations are also calculated. Based on above, it is suggested that, computations of repetitions of the equivalent single wheel load must be considered for the distribution patterns of the truck loads.

6.7 MODEL CALIBRATION

There has been relatively greater work done in the field of inter-city travel demands. Model based on concepts of urban travel demand forecasting can be applied for inter-city freight transport. In the present study the scope was restricted to estimation of inter-city goods movement on road by trucks, therefore following form of gravity model was tested

$$t_{ij} = P_i \frac{a_i (d_{ij})^n}{\Sigma a_j (d_{ij})^n}$$

Based on the data available, it was observed that for six pairs of inter-city goods movement by trucks from/to Allahabad, Lucknow and Agra, model coefficient (n) was calculated using the recorded values of truck volume for the year 1981 and 1991. It is found to be 0.01. To get the realistic idea about 'n', volume of trucks for the year 1992 was estimated by using 'n' as 0.01 in the above equation and compared the observed values with the calculated one. These are nearly matching. Due to various constraints, one is not very sure about the future prediction when only few variables are available but this model could be taken as a starting point and there is a further scope for improvements.

6.8 REMEDIAL MEASURES TO IMPROVE TRAFFIC CONDITIONS

The rough and hazardous movement of trucks and other commercial vehicles, unpredictable behaviour of pedestrians, un-systematic vehicle parking, haphazard and irregular shopping activities and non-traffic uses of the road sides, cause severe road accidents as well as jamming and delays in the smoother flow of the traffic.

For planning of the remedial measures of the road and goods traffic system, the following procedure was adopted :

- Preparation of the road network, identification of critical intersections, stretches and accident prone spots, study of traffic volume and turning movements and identification of critical locations, forecasting of goods traffic for the year 2001, detailed examination of the traffic flow characteristics, generation of various alternatives for short term and long term improvements, evaluation of the various alternatives and selection of the short term and long term measures.

6.8.1 SHORT TERM MEASURES

In order to proceed in solving the traffic problems, which were urgent in nature and were of less time and fund consuming , planning was done for short term basis.

6.8.1.1 TRAFFIC ENGINEERING MEASURES

To stream line the goods traffic movement in Kanpur, road stretches, catering mainly truck traffic were recommended to be improved along with the intersections fall on it. Various traffic engineering measures recommended are as follows :-

- Road widening and proper right visibility is recommended ,for road stretch between Kalyanpur to Rawatpur intersection on G.T. road.

- Kalyanpur and Gurudeo Palace intersections are suggested for improvements in their junction geometrics.

- Road stretch between Naubasta to Afim Kothi, Tat Mill to Kidwai Nagar, Transport Nagar to Juhi Canal, and Yashoda Nagar to Naubasta intersection are recommended for 2 lane extra widening to ensure smoother flow of traffic and proper road side parking. Sufficient night visibility and traffic control devices were suggested for bye-pass road.

- Intersections fall on above stretches were suggested for their geometric improvements and for traffic control devices.

To ensure proper diversion of the trucks, missing links which were recommended for their development are as follows :

- Kalyanpur station (west signal) crossing to Shivli road.
- C.T.I. intersection to Bye pass.
- Panki - Kalyanpur road and Kalpi road.

6.8.1.2 TRAFFIC MANAGEMENT MEASURES

In order to check the congestion level and road accidents from traffic management point of view, improper enforcement and lack of traffic sense have been the main factors. In order to solve this problem, different traffic management measures which were suggested in the study are as follows :

- Total restrictions on heavy goods vehicles on G.T. road stretch between Kalyanpur to Rawatpur intersection. Four

different alternatives were suggested for bye-passing the truck traffic from this stretch.

- Speed limit controls on Kalpi and Hamirpur road.
- Temporal restrictions during day hours i.e. from 9 AM to 9 PM on roads from Bara Devi to Kidwai Nagar intersection, Kidwai Nagar to Tat Mill intersection, Bara Devi to Afim Kothi intersection, C.T.I. to Nand Lal to Bara Devi intersection, from Tat Mill to Ghanta Ghar intersection and from Parade to Ghanta Ghar intersection.
- One-way traffic for road links between Site No. 1 to Baba Kuti intersection, Tat Mill to Kidwai Nagar and Bara Devi to Afim Kothi intersections, Bara Devi to Kidwai Nagar and Naubasta to Yashoda Nagar intersections, Transport Nagar to Juhi canal and Juhi canal side road to Naya pul side parallel roads and between Shivli road and east & west signal crossings on G.T. road.
- Parking restrictions, for trucks on road stretches between Naubasta to Yashoda Nagar, Bara Devi to Kidwai Nagar and for all the intersections within the hundred meters range.
- Planning of well equipped anti-encroachment drive on continuous basis and there should be some specific department which should be specifically made responsible to remove the encroachment from all roads within the city limits.
- Process for heavy financial penalties should be started to ward off floating type encroachment and shop extensions.

6.8.1.3 TRAFFIC EDUCATION MEASURES

It deals mainly with mental reformation and knowledge of the characteristics of traffic, road system and its behaviour. Suggestions for the user and the implementing body are

- Provision of informatory, regulatory and mandatory road signs.

- Educating traffic constables and drivers through written guide lines.

6.8.2 LONG TERM MEASURES

In order to attempt for solving the root cause of transport problem, long term traffic engineering, traffic management and traffic education measures were suggested.

6.8.2.1 TRAFFIC ENGINEERING MEASURES

Traffic engineering measures were suggested for

- Construction of new fly-overs at Kalyanpur, C.O.D. and Medical College crossings.

- Widening of existing three fly overs e.g. Naya pul, Jhakar Kati and Harris ganj bridge.

- Construction of a new bye-pass connecting Bhauti - Bingawan with Rama Devi.

- Construction of new Transport Nagar near Bhauti, connecting the present and proposed bye-pass.

6.8.2.2 TRAFFIC MANAGEMENT MEASURES

Managerial policies are to be framed in order to release the congestion level and safety of traffic. Some of the policies

suggested are -

- Adequate management hands and sufficient number of Police personals, equipped with latest equipments and devices should be employed.

- Establishment of a Transport authority for enforcing the policies for transportation of goods.

6.8.2.3 TRAFFIC EDUCATION

Policies, educating the concerned personnel were suggested and are as follows -

- Road Transport Authority should incorporate certain requisite knowledge of traffic and motor vehicle rules, in its licensing procedure.

- Traffic Police personnel and drivers should have mental exposure to such activity where they can have a fell of existing transport network problems.

REFERENCES

1. Association of Metropolis Development Authority (AMDA) in collaboration with Consulting Engg. Services (CES) " *Traffic and Transportation Study of Kanpur* ", June 1987.
2. Census of India " *Official Records* ", 1982-1992.
3. District Statistics " *Official Records* ", 1991..
4. Hutchinson, B.G. " *Principal of Urban Transportation System Planning* ", Mc Graw Hill.
5. Janson, C.Yu." *Transportation Engineering (Introduction to Planning Design and Operations)* ", Elsevier North Holland,Inc. New York.
6. Kanpur Development Authority " *Official Records* ", 1992.
7. Kanpur Municipal Corporation " *Official Records* ", 1982
8. Marwah, B.R. (1976) " *Studies in Stochastic Modelling and Simulation of Mixed Vehicular Traffic* " , Ph.D. Thesis Dept. of Civil Engg. I.I.T. Kanpur.
9. Marwah, B.R. and Singh, D.,(1979) " *Analysis of Road Accidents in Kanpur* ", I.R.C. New Delhi
10. National Transport Planning and Research Center (NATPAC) " *Comprehensive Traffic and Transportation Planning Studies In U.P.* " , December 1991.
11. R.T.O. Kanpur, " *Official Records* ", 1982-1992.